Farlow (W. G.)

All by

Farlow (W. G.)

BOTANICAL ARTICLES

EXTRACTED FROM THE

BULLETIN OF THE BUSSEY INSTITUTION,

MARCH, 1876.

Respects of W. G. Farlow

BOTANICAL ARTICLES

EXTRACTED FROM THE

BULLETIN OF THE BUSSEY INSTITUTION,

MARCH, 1876.

No. 21. — *On a Disease of Olive and Orange Trees, occurring in California in the Spring and Summer of* 1875. By W. G. Farlow, Assistant Professor of Botany in Harvard University.

During the past summer, numerous complaints have come from southern California of a fungus which had attacked the olive and orange trees, and which was causing a considerable loss of those two crops. Our attention was first called to the subject by Dr. H. W. Harkness, who, in a letter from San Francisco dated May 11, sent a specimen of the fungus on an orange-leaf from southern California. Of the extent of the ravages of the fungus at that date no information has been received; but, as in a letter from San Diego, dated June 3, Mr. D. Cleveland * wrote that there was no trace of the fungus in that vicinity, we may suppose that the disease first appeared not far from Santa Barbara, where we have definite knowledge of its occurrence, and where great damage was done later in the summer. In a letter from Dr. George Thurber dated September 20, enclosing some specimens of the fungus, is the following from a correspondent in Santa Barbara: "We are troubled with our olive, lemon, and orange trees. A small fungus appears on the leaves, twigs, and branches, at first visible only with a microscope, and of a green color. As it increases in size it turns brown, and then black. The olive is so exhausted that it is unable to fruit. The orange and lemon stand it better, but their fruit is so inferior as to be practically worthless." On the day of the receipt of Dr. Thurber's letter, another was received from Professor Dana, also enclosing specimens from Santa Barbara.

From the general tenor of letters from California, it is evident that, if this is not the first year of the appearance of the disease, it is, at least, the first in which it has attracted general attention; that its effect on the olive and orange crops has not been slightly, but markedly injurious; and that, in its advanced stages, there is present on the leaves and stems a blackish substance, which is universally regarded, by

* We are in receipt of a letter from Mr. Cleveland, dated early in January, 1876, in which he sends specimens of the fungus on orange-leaves, which, he writes, is at that time common at San Diego.

those who have formed any opinion on the subject, as a fungus. We have received, at different times, from California specimens of leaves and stems of orange and olive trees covered with the black growth, and have been able to study the fungus, which presents some points not without interest in a botanical point of view; and, if our conclusions do not point to a direct remedy, it will be conceded, we hope, that we have contributed towards removing some misconceptions as to the nature of the disease. At this distance, remote from all opportunities of observing the disease on living trees, there are, of course, some points in the development of the fungus which we have not been able to study; and our correspondence has not been sufficiently extensive or minute to enable us to give any statistics of the ravages of the disease, to ascertain the climatic or other changes which have preceded or accompanied the breaking out of the epidemic, or to decide whether it is the same form of disease which has been reported to occur in Florida. Our specimens present the disease as it appears when in a somewhat advanced stage, and after the leaves and stems have become so changed as to attract attention.

Mycelium. — The leaves of the olives which are affected by the disease are somewhat curled and shrivelled, and are of a browner color than normal leaves which have been gathered but a few weeks. On both surfaces of specimens sent us are black spots of greater or less extent, but in no case is the leaf perfectly black. On the upper surface the black spots are more numerous, more distinct in outline, and harder in substance, than on the lower, where they were more diffuse and of a powdery consistence. The twigs, of which we received only small specimens, are covered with spots which resemble more closely those on the upper than on the lower surface of the leaves. In one specimen the spots are nearly confluent, and the bark is visible in only a few places. After the leaves or stems have been soaked in water for a short time, the black substance can be scraped off without the least trouble, leaving the bark tolerably clean. The black substance, when seen with a magnifying power of four hundred diameters, is found to be composed of the stellate hairs peculiar to the olive, over which is growing a fungus, to the dark color of whose mycelium the spots owe their color. The mycelium is very variable in appearance. As a rule, it is composed of moniliform hyphæ, whose cells are .006 mm. by .008 mm., and in some places almost spherical. The color of the

cell-wall is a dark or purplish brown, and in most of the cells there is a comparatively large-sized oil globule. These hyphæ branch in all directions, and the cells of the branches grow constantly longer, narrower, and paler, although, in all cases, retaining a tinge of brown. The relation of the mycelium to the stellate hairs and outer part of the twigs and leaves is clearly seen in cross sections. The hyphæ run along the surface of the epidermis and of the hairs, which it will be remembered resemble a broadly-opened, short-handled parasol. They are twined closely round the stems of the hairs, so closely, that the fungus cannot be removed without tearing them off. They do not enter into the cells of the olive, and there are no haustoria as in the case of some of the leaf parasites belonging to the *Erysiphei.* Occasionally there are little knob-like projections of the cells which seem to indicate haustoria ; but, by the most careful examination which we have been able to make, we have not been able to see that they enter into the cells of the stellate hairs or epidermis and act like haustoria. The surface of the hairs and epidermis, however, seems covered with a sticky substance (of which we shall have more to say hereafter), to which the hyphæ closely adhere. Plate 1, Fig. 2, shows one of the stellate hairs seen from below, with a portion of the mycelium growing upon it.

Various modifications of the mycelium are found principally on that portion growing on the outer part of the stellate hairs exposed to the air. After reaching a certain stage of development, they grow together in such a way that the hyphæ coming together laterally form a sort of membrane, as shown in Plate 1, Fig. 1, *d.* This membrane is composed of only one thickness of cells, but is very uneven as it follows and conforms to the inequalities of the hairs. Its general direction is parallel to the surface of the leaf or stem on which it is found.

CONIDIA. — The hyphæ, at their free ends, branch in all directions, and bear reproductive bodies of several kinds. The simplest form is that shown in Plate 1, Fig. 3, *d*, where the ordinary cells of the mycelium divide by cross partitions into two parts, which do not respectively grow to the same shape as the mother cell, but remain together two by two, as shown in the figure ; the hypha becoming zigzag by the alternate lateral displacement of the pairs of cells, which finally drop off and readily germinate, each cell producing a germinal tube. In other parts of the mycelium, the terminal cell of certain threads di-

vides by means of partitions, parallel to and at right angles to the axis of the filament, until a compound body is formed, which resembles the spores of the so-called genus Macrosporium. These bodies, which can only be described as irregular conglomerations of cells of an oval outline, are produced in great abundance, and average .015 mm. by .025 mm., but are often much larger, though often smaller. They easily drop from their attachments and germinate, each cell being capable of producing a germinal tube. Other hyphæ, rising at right angles to the plane of the membranous portion of the mycelium, grow more and more attenuated, and branch at the tip; the terminal cells divide in two, as in Plate 1, Fig. 3, *c*, fall from their attachment, and germinate. This last modification of the hyphæ, which is by no means so common as the two previously described, will be recognized as corresponding to the so-called genus Helminthosporium, or Cladosporium, if we examine before the terminal cells have divided. It is out of the question to give specific names to such forms as those just described, which, since the publication of Tulasne's "Carpologia Fungorum," are known to be different states of development of species of Pyrenomycetes.

PYCNIDIA. — Besides the forms already described, there are other bodies of a more complicated nature. Plate 1, Fig. 3, *a*, *a*, represents the *pycnidia*, which are quite numerous in the spots, both on the leaves and the stems. Their general shape is spheroidal. They consist of a membranous sac of the same color as the darker parts of the mycelium, in which are contained the small bodies, which are represented as being discharged in Fig. 3, *b*. Their average diameter is .04 mm. In general appearance, the pycnidia resemble so closely those with which every one is familiar in other Pyrenomycetes, that any further description is unnecessary.

STYLOSPORES. — In examining the larger black spots on the stems of the olive, other bodies are seen, — the *stylospores*, to adopt Tulasne's nomenclature. They are represented in Fig. 1, *a*, and resemble flasks, whose long necks project beyond the mycelium, by which they are surrounded. They may be recognized by the naked eye, and clearly seen with a hand-lens, as the black projecting necks are tolerably conspicuous. To obtain a good view of them, some of the larger black spots must be picked to pieces, and the fragments treated with caustic potash, and afterwards hydrochloric acid. The shape of the separate

flasks is quite variable. The central portion of Fig. 1 represents one of the more regular, where, starting from a somewhat contracted base, there is a regular swelling of the central portion, which again diminishes into a rather long neck of uniform size. In some cases, the flask, instead of being straight, is flexuous with two swellings, the upper one being smaller than the lower. Others, still, fork, and usually one branch is much more obtuse than the other. The size of the flasks varies very much; but, even in their younger states, they can generally be distinguished from the pycnidia by being less inclined to a spherical shape. The height is as variable as the outline. Some of the smaller are .15 mm. high; others — and they are nearer the average — are .4 mm. The wall of the flasks is composed of dark-colored cells, which are longer in the direction of the axis of the flasks.

In some cases, the cells, composing the wall of the stylospores, grow outwards, so as to form papillæ; and, as the mycelium at the base generally sends up branches around the flask, it is only by a careful dissection that the base can be clearly seen. At first, the mouth is closed, and there is a depression of the cells at the centre; but, later, they spring back so as to form, round the open mouth, a circle of slightly reflexed teeth, whose tips are perfectly hyaline. The neck of the flask is hollow; but, in the swollen portion, spores are borne. They are oval, and divided into four parts by cross partitions. They are not contained in asci, but are attached to short filaments which line the surface of the base and lower portion of the sides of the flask. They escape readily through the open mouth; and slight pressure on the covering-glass generally causes a fresh discharge.

So far, we have spoken of the fungus as seen on the olive. The orange-leaves sent us are also covered with a black substance, which is not so much in spots as in powdery sheets upon both surfaces of the leaves, more particularly the upper. The attachment to the leaf is by no means as strong as in the olive; and the deposit can easily be scraped off, even without previous moistening. In fact, in some places it falls off on the slightest touch. No specimens of diseased orange-stems were received for examination. A microscopic examination shows why the deposit was more easily removed from the orange than the olive leaves. The smooth surface of the former gives no permanent attachment to the fungus, which, as we have before said, does not penetrate into the interior of the cells of the mother plant; while, on

the other hand, the hyphæ wind themselves tightly around the stalks of the stellate hairs of the olive, from which they cannot be removed. If the fungus should attack both oranges and olives, it is very evident why the latter would suffer much more than the former. Apart from the absence of hairs, which invariably constitute a large proportion of the scrapings of the olive-leaves, that from the orange-leaves is precisely identical, — the same moniliform hyphæ, bearing Macrosporium and Helminthosporium spore-like bodies, the same pycnidia and stylospores. Micrometric measurements only confirm the identity. On the orange-leaves sent me, there is a greater proportion of pycnidia, and a smaller proportion of stylospores, than in case of the olive-leaves; but that is, of course, an accidental difference, as the olive-leaves themselves vary. On the orange, the proportion of Helminthosporium-like spores is much greater than on the olive: but, from the facility with which the so-called secondary forms of fruit are produced in fungi, and their great variability, that is not a fact of any importance; and we can in the most decided manner affirm that the fungus is the same on both plants.

The first account of a fungus growing upon orange-trees, resembling in its habits that received from California, was given by Persoon, in his Mycologia Europæa, p. 10, published in 1822. His description of the new fungus is very briefly given in the following words: "Fumago Citri, late effusa crassiuscula nigro-grisea. Provenit in Europa meridionali ad folia Citri Medicæ, quæ sæpe tota induit." Later, Turpin published an account, with a figure, of a species which he also called Fumago Citri, which Montagne made the type of a new genus, Capnodium, published in the Annales des Sciences Naturelles, 3 série, tome 11, 1849. Montagne seems to have had doubts as to the identity of the Fumago Citri of Persoon with that of Turpin. Almost simultaneously with the publication by Montagne of his genus Capnodium, Berkeley and Desmazières published, in the Journal of the Horticultural Society of London, vol. iv. p. 252, an article "On some Moulds referred by Authors to Fumago." In this communication, there is the following description of the orange fungus briefly referred to by Persoon and Montagne: "Capnodium Citri, Berk. and Desm. Sparsum, setosum; peridiis elongatis; mycelio ramoso moniliformi pulcherrime reticulato; sporidiis oblongis minutis. Fumago Citri, Pers., Myc. Eur., vol. i. p. 10; Turpin l. c. On leaves of different species of Citrus. France: Persoon, Léveillé."

Of fungi occurring on olive-trees, we have an early account by Montagne in the Annales des Sciences Naturelles, 3 série, tome 12, 1849, of a fungus mentioned in the "Bull. Soc. centr. d'agric.," 2 série, iv. p. 267, under the name of Antennaria elæophila, which had been found at Perpignan in 1829, which caused ravages somewhat the same as the California fungus, and which had previously been referred by him to Cladosporium Fumago. It was probably the same plant as the Torula Oleæ of Castagne. Tulasne, however, in the "Carpologia Fungorum," vol. ii. p. 279, showed that the Friesian genus Antennaria was the pycnidial state of species of fungi of which Capnodium was the ascigerous state. He restored the old name, Fumago, and gave a detailed account of Fumago salicina, which was illustrated in his unrivalled manner.

The fungus from California is evidently the same as that which has been known in Europe since 1829. We have examined two authentic specimens of Antennaria elæophila Mont., — one from the Duby Herbarium, the other from that of De Notaris, — and the structure is precisely that of the pycnidial-bearing portion of the California fungus. The stylospore-bearing portion of our fungus is the Capnodium Citri of Berkeley and Desmazières, to which they refer the Fumago Citri of Persoon and Turpin. Montagne had observed only the pycnidial form — his Antennaria elæophila — on olives; whereas, on the orange, he found only the stylospore form, — his Capnodium Citri. Berkeley and Desmazières make mention only of stylospores on species of Citrus. We have been so fortunate as to find, on the specimens from California, both pycnidia and stylospores, and on both olives and oranges, — which proves the identity of Antennaria elæophila (Mont.) and Capnodium Citri (Berk. and Desm.). The perfect ascigerous state of the fungus we have not found; nor do Berkeley and Desmazières seem to have met with it, for they add to their description, "asci have not been observed." We have not been able to find any recorded instance of asci having been found in Capnodium Citri. Tulasne remarks, — quite pertinently, as it seems to us, — that, until better known, Capnodium Citri and Antennaria elæophila can scarcely be considered distinct from Fumago salicina.* The specimens from

* "Donec melius cognoscantur, a Fumagine salicicola supra descripta ægre etiam discriminantur, nisi sede sibi singulis assueta, tum *Fumago Citri*, Persoonio seu *Capnodium Citri* Montanio; tum etiam *Antennaria elæophila,* Montanio," &c. (Selecta Fungorum Carpologia, pp. 283, 284.)

California certainly seem to strengthen Tulasne's suspicions; and we must confess ourselves quite unable to distinguish between Fumago salicina — found on willows, oaks, birches, hawthorn, quince, and pear — and Capnodium Citri, found on oranges, and, as the Californian specimens show, also on olives. If it be said that no asci have been seen by us, that is no reason why the fungus should be removed from Fumago salicina, which, in the conformation of its mycelium, its conidia, pycnidia, and stylospores, it most closely resembles. Evidently, in the group of fungi which we are considering, too much stress must not be laid on the length and shape of the stylospores. We see, in the specimens before us, how great is the variation in what is undoubtedly a single species. Neither is the fact of the branching of the stylospores very significant, as, in the present case, there are both simple and branching stylospores. If the reader will compare our Plate 1, Fig. 1, with that of Fumago salicina, by Tulasne, "Carp. Fung.," Plate XXXIV., Figs. 14 and 20, — leaving out of sight, as far as possible, the different artistic merits of the two, — we think he will admit, that, in all essential particulars, they are alike. In reality, the resemblance is even greater than the limited size of our drawing would indicate. We have said that we found no asci; but Plate 1, Fig. 1, *c*, would seem to be the early stage figured by Tulasne, l. c., Fig. 20. The asci will probably be found in California; and we do not doubt that they and their contained spores will prove to be like those of Fumago salicina.

If we seem to the reader to have gone too minutely into the consideration of the systematic position of the fungus, it was for the purpose of bringing out more forcibly the fact that it is nothing new, or peculiar to California; and that it is not even limited to orange, lemon, and olive trees, but, as we have seen, is found on a number of other trees. How does it happen, then, that a fungus so widely diffused should suddenly increase to such an extent as to injure two important crops? We remarked, in passing, that the hyphæ seemed to be, as it were, gummed to the stellate hairs, and, in some cases, to one another, by a sticky substance. We do not forget, that, when any mycelium is growing on a leaf, a certain amount of dirt — including, of course, some oily matter — is sure to be entangled in its meshes. In the case of the present fungus, however, there is something more than an accidental accretion of such substances. The surface of the leaves

and stems is in many places covered with a gummy deposit, presumably of insect, certainly not of fungus, origin. On this gum, the fungus grows luxuriantly; and, although it may be found on those parts of the leaves where no gum can be seen, yet it is evident that it has reached such places by growing from the gummy spots. Of the origin of the gum, other than that it does not come from the fungus, we have no theory of our own to advance. Remains of insects are abundant on the leaves; but, being entirely ignorant of entomology, we cannot say what their relation is to the diseased trees. It may be that they are stray visitors caught in the gum. The fungus grows most luxuriantly on the remains of insects which I have seen, which, in some cases, present a ludicrous spectacle, the hyphæ projecting from them like the quills of a hedgehog.

It has often been asserted by botanists that fungi, of the group to which ours belongs, are particularly inclined to attack trees which have been previously infested with insects. In 1849, Berkeley, in the London Journal of Horticulture, described a fungus occurring in Ceylon on coffee, — Triposporium Gardneri, — which followed the appearance of a species of coccus which was described in the same journal by Mr. George Gardner. In their paper on moulds referred to Fumago, Berkeley and Desmazières make the following statement: "They are often, if not always, preceded by honey-dew, whether arising from aphides, or from a sugary excretion from the leaves themselves. Frequently, too, they are accompanied by some species of coccus, especially in the genus Citrus." Tulasne* does not agree with the writers just mentioned, as will be seen by the reference. He begins his description of Fumago salicina, however, with the following words: "Initio fungillus e membranula constat tenuissima, alba et hyalina, matricique vivæ instar gummi soluti illitus hæret, quamvis

* Quibusdam observatoribus visum est *Fumagines* in fructicibus potissimum provenire quos aphides primum occupassent, tamquam si ex humore dulci quem bestiolæ istæ emittunt, aut ex latice viscido quem matrix ab iis læsa copiosum aliquando stillat, suum pabulum traherent; necessitates autem hujus modi duplici de causa minime verisimiles censemus. Hinc enim sexcenties nobis contigit *Fumagines* luxuriantes videre in arboribus, omnis aphidum generis prorsus expertibus; illinc *Fumagines* vere parasitari constat, succis scilicet alienis uti ex his vivis. Super hoc argumento conferas tamen quæ attulit Berkelæus in tomo iv. (1849) Ephemeridis Soc. Hortic. Londinensium, nec non Georgio Gardner commentatiunculam ibidem (pp. 1–6) editam circa the Coffee-bug and Coffee-mildew. (Carp. Fung., ii. p. 280.)

ab eadem, maxime si fortuito ea aruerit, frustulatim aliquando secedat. Id cuticulæ struunt utriculi, perexigui, . . . oleo pallido tandem repleti," &c. This initial stage described by Tulasne is figured in Table XXXIV., Fig. 2, mm., l. c. We must confess that the expression, "matricique vivæ instar gummi soluti illitus hæret," seems a little indefinite, but the figure looks exceedingly like a collection of oil-globules, or very small eggs. We do not pretend to say that what Tulasne saw was not a membrane of vegetable substance, — a part of the fungus itself; but, in the Californian specimens, we had something which looked very much like the mm. of Tulasne's figure, and, in this case, we have satisfied ourselves, by observation and experiment, that it is of animal nature, and not a part of the fungus, which, instead, was growing upon it. It is a little difficult to understand, from what is already known of the development of fungi, how any fungus could begin as a very thin membrane, composed of small cells filled with oil. The initial stage of fungi, if we except the Myxomycetes, as far as we know, is filamentous, not membranous.

The result of our examination of the diseased orange and olive leaves is briefly as follows: The disease, although first attracting the eye by the presence of a black fungus, is not caused by it, but rather by the attack of some insect, which itself deposits some gummy substance on the leaves and bark, or so wounds the tree as to cause some sticky exudation, on which the fungus especially thrives. It is not denied that the growth of the fungus greatly aggravates the trouble already existing, by so encasing the leaves as to prevent the action of the sunlight: we only say, that, in seeking a remedy, we are to look further back than the fungus itself, — to the insect, or whatever it may be, which has made the luxuriant growth of the fungus possible. With regard to the fungus, we are able to assert that it is the same on both olives and oranges, — the species described by Berkeley and Desmazières under the name of *Capnodium Citri*, which seems to us, together with the pycnidial state described by Montagne under the name of *Antennaria elæophila*, to be but two states of a species identical with that described by Tulasne as *Fumago salicina*. It remains yet to find the asci on olives or oranges, which will probably be accomplished without difficulty in California. The earliest stages of the fungus should be studied by some one living near orange-groves; for, although the disease has been known to attack greenhouse plants, it is

not very common, or, in that case, so favorable for study. Especially is it to be desired that careful notes of the extent and manner of appearance of the disease, and the climatic and hygrometric conditions attending it, should be carefully recorded.

As a remedy, alkaline soaps, as strong as the trees will bear, will no doubt prove advantageous in case of the oranges; but, in the case of the olives, much less good is to be expected, owing to the presence of the stellate hairs on leaves and twigs. With this, our notice of the disease from a botanical stand-point ends; and we commend the subject to the attention of entomologists.

No. 22. — *On the American Grape-Vine Mildew.* By W. G. Farlow, Assistant Professor of Botany in Harvard University.

There are, probably, no plants in general cultivation in this country which are attacked by a greater number of fungi, or rather by fungi to which a greater number of names has been given, than the different species of grapes. We have under cultivation not only our native species of Vitis with the fungi peculiar to them, but also the imported varieties of Vitis vinifera, accompanied, also, by their own special maladies. In his List of the Plants of North Carolina, Curtis enumerates no less than eighteen species of fungi found exclusively, or almost exclusively, on species of Vitis; and to this number might be added others which, although common on grape-vines, are also found on other plants. It is a mistake to suppose, however, that the species enumerated are all really distinct from one another. On the contrary, the genera, *Phoma*, *Diplodia*, *Septoria*, and others are nothing but secondary forms of genera of Ascomycetous fungi, of which several representatives, *Rhytisma Vitis*, Schw., *Tympanis viticola*, Fr., *Diatrype viticola*, Schw., *Valsa Vitis*, Schw., and others are found on our grape-vines; and it may appear, in the end, that the supposed variety of fungi is not so great after all; but, like the bill of fare presented by the obliging waiter, nothing more than ram, lamb, sheep, and mutton. We are, as yet, in ignorance as to exactly which of the ascigerous forms, the secondary forms belong, and, until we have a more complete knowledge of the subject, distinct, specific names will still continue to be given to the latter. It is to be hoped, however, that, the time is not remote when we shall have such a knowledge of the development of the different fungi which are found on the grape, as to enable us to dispense with the superfluous specific names which represent, as it is, our ignorance rather than knowledge.

The grape disease, properly speaking, that which has proved so disastrous at different times to the vines in Europe and Madeira, is caused by a fungus to which Berkeley has given the name of *Oidium Tuckeri*. All we know of this fungus botanically is, that it is the conidial form of some species of Ascomycetes, probably some *Erysiphe*. The perfect fruit has never been found on the vine in Europe. The

same *Oidium* has been reported in several places in this country; but, inasmuch as *Oidium Tuckeri* is the general name given to any white mould on grapes by those of our botanists who have not made a special study of fungi, the information is not always trustworthy. Undoubtedly a form undistinguishable from the *Oidium Tuckeri* of Europe does occur in this country,* but to what extent is uncertain. During the past summer, the grape-vines at Amherst, Mass., were attacked by a fungus which was supposed to be *Oidium Tuckeri*, and which was distributed as such. The fungus was the *Uncinula spiralis* of Berkeley and Curtis, of which the conidia are almost, if not quite, identical with *Oidium Tuckeri*. Perithecia were abundant on the specimens we have examined, and the connection between conidia and perithecia could be traced. We are not aware that the perithecia of *Uncinula spiralis* have ever been found in Europe, and it is doubtful whether the fungus of the European vines is really that species. At any rate, it must be admitted that, as used in this country, the name *Oidium Tuckeri* is somewhat indefinite, and does not necessarily refer to the same fungus as in Europe. Whatever forms may, correctly or incorrectly, be included under *Oidium Tuckeri*, as far as our experience goes, none of them is by any means as common, certainly not in New England, as another fungus, *Peronospora viticola*, B. & C., which is limited to the leaves and stems, and does not attack the fruit. This fungus is peculiar to America, and we have attempted in the following pages to give a history of its development.

Although extremely common, the fungus in question is not one very likely to attract the attention of those not somewhat interested in fungi. It first appears on the under surface of the leaves, which, in most of our native species of Vitis, is so covered with whitish wool that the fungus, which is of nearly the same color, escapes notice. Later, it causes a curling and drying up of the leaf, which then passes for any ordinary dead leaf. The fungus makes its appearance about the first of August; and, at any time from the middle of the month until frosty weather sets in, one can be almost certain of finding it. As we

* In the Curtis Collection the only American specimen of Oidium Tuckeri is one marked 3723 on Vitis rupestris, Texas, Lindheimer. No. 3610, Michener (538) on Vitis Labrusca, Pennsylvania, 1851, and Nos. 292 and 399 Russell, Mass., September, 1856, on cultivated grape-vines, are the original specimens of Uncinula spiralis, B. & C.; and a figure of the asci and appendages is given in Berkeley's "Introduction to Cryptogamic Botany," p. 278, fig. 64.

have already said, it makes its appearance first on the under surface of the leaves, most abundantly on the veins near the petioles, and afterwards in spots all over the under surface. It is most easily recognized on *Vitis cordifolia*, where the under surface of the leaves is smooth, and where the frost-like substance of the fungus is in strong contrast with the green leaf on which it grows. When growing on *Vitis Labrusca*, *V. æstivalis*, or cultivated varieties of those species, it appears in the form of spots, at first pure white, afterwards rusty, slightly raised above the level of the hairs with which the lower surface of the leaves is clothed. Sometimes, and, except in *Vitis cordifolia*, we have not found it to occur at all frequently, the fungus invades the petioles of the younger leaves and the stems which swell to considerably more than their usual dimensions. As the disease advances, the fungus spreads over the whole of the lower surface of the leaves, until, as not unfrequently happens, scarcely a healthy leaf remains; red spots appear, at first small, afterwards larger; the leaf becomes dark brown, shrivels up, and becomes very brittle, but it does not fall from its attachment at once, as we should expect. The fungus, like all the other species of the genus, flourishes best in moist warm weather, but seems more tolerant of dryness than any other Peronospora with which we are acquainted. We have allowed leaves to remain exposed for some days on a table in the dry atmosphere of a laboratory, and fresh conidia were produced for several days even when the leaf seemed quite dry. During August, the disease, in the region of Boston, advances gradually until, towards the middle of September, almost every leaf is affected and hangs dead upon the branches.

Mycelium. — A microscopic examination of the leaves and stems shows an abundance of mycelial threads or hyphæ. They are from .008–.0122 mm. in diameter in the stem and petioles, but are generally smaller in the leaves. In the stem, their general course is up and down, and they are found in all parts, except the wood proper where they do not penetrate. The contents of the hyphæ are granular and somewhat oily, and there are but rarely any cross partitions. They force their way in all directions between the parenchymatous cells, and into them by means of haustoria, Plate II., Fig. 3, *a*, which are abundant, especially in the stem. The haustoria are usually not more than half the diameter of the hyphæ, and resemble strongly those of *Cystopus candidus*, being spherical and connected with the hyphæ

by slender necks. A magnifying power of three hundred diameters is sufficient to show them plainly. In the leaves, the hyphæ are found in all parts except the vascular bundles, and are more irregular in diameter than in the stem, being often swollen in a varicose manner. Just beneath the stomata, the hyphæ are particularly abundant and intricately entangled. Those which are destined to bear the conidia pass through the stomata being constricted in their passage and expanding afterwards, so that when cut off from the surface of the leaf they seem to have a bulbous base. Sometimes such a large number of hyphæ force their way through a single stoma that the two cells which bound it are torn asunder.

However large a number of hyphæ may force their way through, a small number, from four to eight, grow faster than the rest and bear the conidia. The conidia-bearing hyphæ vary from .2 to .6 mm., in height when fully matured. Their general habit of branching is shown in Plate II., Fig. 1. The tip of the simple axis divides into three parts, one of which generally seems like the direct termination of the axis and the other two as lateral offshoots, given off at about the same level. At the base of each of the two lateral offshoots, two similar secondary offshoots are again given off as shown in Plate II., Fig. 2, which represents a highly magnified view of a tip of a stem in which *a* denotes the primary divisions and *b* the secondary. The third division of the primary branch on the left is behind, and concealed from the observer by the branch itself. The same form of division takes place at the tip of the branches and their subdivisions, so that the ultimate ramifications always seem three-parted. The branches, which are few in number, generally from four to eight, are placed alternately on the upper third of the axis, being generally, but not always, distichously arranged. Relatively to the main axis, they are all short, the broadest expansion from side to side not being usually greater than .12 mm. The branches are furnished with branchlets of a second and third order as shown in Plate II., Fig. 1, where the naked lower portion of the stalk has been only partly represented. The general arrangement of the conidia-bearing hyphæ, it will be noticed, is more compact than in most species of Peronospora, the ultimate branchlets being very dense. The conidia are borne in profusion on the tips of the hyphæ. They are of an oval shape, obtuse, and without the papilla found in some species at the remote end, but slightly

acute, and with a short projecting point at the attached end. Their size is very variable, the smaller being .0085 mm. by .0125 mm. and the larger about .017 mm. by .03 mm.

GERMINATION. — The germination of the conidia was studied by us in the beginning of October, when the fungus was in its prime. Leaves affected with the fungus were gathered in the afternoon, and allowed to remain under a moistened bell-glass during the night. In the morning, parts of the leaves where fresh conidia had grown during the night were cut out, and the conidia shaken into watch-glasses, or on to glass slides containing a few drops of water. In order to test the conditions of germination, some of the bell-glasses were placed in a light room, and others kept in the dark, and sowings were made at different hours of the day. The result was uniformly the same, whether the conidia were in the dark or the light. Experiments in direct sunlight were, however, unsuccessful, as the sun's rays heated the water to such an extent as to cause rapid evaporation of the necessarily small amount of water used. With relation to the time of day at which the sowing was made, germination took place in all cases; but the conidia sown in the morning generally germinated somewhat more quickly and more abundantly than those sown in the afternoon. This might have been partly owing to the fact, that the conidia sown in the morning were in better condition, the result of a growth of fourteen or fifteen hours; while those sown in the afternoon were the conidia produced during only four or five hours of the forenoon. It was not possible to keep the conidia which were produced in the night until the afternoon, as they generally fell from their attachments in the morning, and began to germinate. In all cases, the germination took place with a surprising regularity. At the end of an hour, the conidia were slightly swollen and their contents had begun to segment, as shown in Plate III., Fig. 4, each segment having a light-colored nucleus. At the expiration of an hour and a quarter, the segments had resolved themselves into a number of oval bodies, which collected at the distal end of the conidia, and which, before long, succeeded in rupturing the cell wall and making their escape from the mother-cell. They passed out rather slowly, usually one at a time, and paused for a moment in front of the opening, where they remained as if not yet quite free from one another. In a short time each segment began to extricate itself from the common mass, moved more and more actively,

and, finally, darted off with great rapidity a full-fledged zoöspore furnished with two cilia. The number of zoöspores produced in a conidia is very variable. The most frequent number is five or six. Sometimes there are not more than three, and we counted in one case seventeen. Not unfrequently one or two of the zoöspores do not succeed in escaping from the mother-cell, but they are seen to move about inside. Where two remain, it often happens that, by trying to move in opposite directions, they prevent one another from passing out at the open mouth of the conidia. The shape of the zoöspores can hardly be described, as it is continually changing. Plate III., Figs. 6, 7, show two of the most common forms which they assume. At times, they are irregularly oval, flattened on one side, and more acute at one end than at the other. There are always two bright spots near the flat edge, from which two cilia project in opposite directions. In other cases, the zoöspore rolls itself up into a ball, the two bright spots are brought almost in contact with one another, and the cilia project nearly parallel to one another. Plate III., Fig. 7. The length of the zoöspores varies from .008 mm. to .010 mm. They move about for from fifteen to twenty minutes, the motion growing gradually slower. At the end of that time they come to rest, the cilia drop off, they assume a spherical shape; and, in about a quarter of an hour, an outgrowth appears on one side which develops rapidly into the mycelium of a new plant. Under no circumstances have we seen any direct production of a hypha from the conidia itself as sometimes happens in *Peronospora infestans.*

The regularity and punctuality with which germination takes place, notwithstanding the variations in light, heat, and other external conditions, is quite surprising. It is so regular that by properly arranging the time of sowing, and first making sure that the conidia used are quite ripe,* we are able to be tolerably certain of a crop of zoöspores for class demonstration at any given hour. At the end of an hour, or an hour and a quarter, the conidia will have begun to swell; a quarter of an hour later, the zoöspores will have been discharged; in another quarter of an hour they will have come to rest; and in another quarter of an hour they will have begun to germinate. Time and time again have we sat with watch open before us to observe

* To make sure of this, it is better to shake a piece of a diseased leaf over the water to be used, rather than to plunge it into the water.

the changes which might occur from the end of the first hour until the beginning of the following quarter-hour; and almost punctually to the minute, the discharge of zoöspores has begun. When the conidia sown are in good condition, the greater part of them emit their zoöspores during an interval not greater than fifteen or twenty minutes; and those which during this period do not discharge their contents in the form of zoöspores do not do so at a later period, but abort. When the conidia are sown in the afternoon, however, it sometimes happens that a part of them do not germinate until the next morning.

OÖSPORES. — We have found the oöspores of *Peronospora viticola* only on plants of *Vitis æstivalis*, where they are apparently abundant, although not very easily seen. They are found in the latter part of September and October, in the discolored, shrivelled parts of the leaves, and are most abundant just inside what are called the palisade cells of the upper surface. They are spherical, about .03 mm. in diameter, have a thick cell wall, which is smooth and slightly yellow in color, and almost completely fill the mother-cell, as shown in Plate III., Fig. 2. The dense structure and opacity of the upper surface of the leaf and the dense woolly covering of the lower surface, which can be entirely removed only with great difficulty, renders this species one of the least favorable of the genus for the study of the formation of the oöspores. In dried specimens, the oöspores can be well seen only after boiling in potash, afterwards treating with hydrochloric acid, and a careful dissection, a process, it will be easily imagined, likely to distort the parts.

The oöspores are generally set free by the cracking open, or, more slowly, by the rotting of the palisade cells, which allows the escape of the oöspore with its tough covering. The germination of the oöspores we have not been able to discover.

The fungus we are now considering is very abundant on *Vitis æstivalis*, Michx., *V. Labrusca*, L., and all their cultivated varieties; on *V. cordifolia*, Michx.; on *V. vulpina*, L., and the cultivated Catawba grape; and, in fact, on nearly all varieties of American grapes, although we have not as yet heard of its occurring on the Diana grape. It is probably found throughout the whole United States east of the Rocky Mountains, but it has not yet been reported from the west coast. It has been said not to occur on the smooth-leaved species, but its presence on *V. cordifolia* proves the contrary. It has also been said that it does not

occur on the varieties of *V. vinifera* growing in this country. As we have not had an opportunity in this region of examining such varieties growing in the open air, we cannot controvert this point; but our experiments prove that it can be made to grow on *V. vinifera* even more luxuriantly than on American species.

To study the propagation of the disease, leaves of different species were kept under moistened bell-glasses, and conidia were sown on them in different positions. The quickest method of infection was by laying a healthy leaf upon one affected with the fungus. In two cases, the fungus appeared on the healthy leaf at the end of the second day. It made no difference whether the upper or lower surface of the healthy leaf was brought in contact with the infected leaf, as far as the contagion was concerned. Again: germinating zoöspores were sown on the upper and lower surfaces of healthy leaves of *Vitis vinifera*, and of smooth-leaved American species. The fungus appeared first on the leaves of *V. vinifera*, on the fifth day after sowing, and grew luxuriantly, soon covering the leaves. On American species, it made its appearance a day or two later. Where the zoöspores were sown on the leaf, the best results were obtained when sown on the lower surface. This is, perhaps, owing to the fact that the under surface of the leaves is concave, and readily holds the water used in the cultures, while the upper surface is somewhat convex.

In order to find out in what way the hyphæ produced from the zoöspores make their way into the vine, small slices of petioles were placed on moistened slides, on which were germinating conidia. In only one case was a direct result obtained; and then the germinal thread passed through the epidermis, and not through a stoma. On this point, however, our experiments were not sufficiently numerous to prove satisfactory.

One would naturally suppose that a fungus so common as *Peronospora viticola*, which often is found on every leaf of a vine, would have an injurious effect upon the grape crop. Such, however, is not the case. The fungus does not attack the grapes themselves; nor does it, at least in New England, appear until about the first of August; and its withering effect upon the leaves is not very evident before September. As far as out-of-door grape culture in the Northern States is concerned, we are inclined to believe, that, practically no harm is done by *Peronospora viticola*, but that, on the contrary, the fungus

is really beneficial. Our native vines have a luxuriant growth of leaves; and the danger is that, in our short summers, the grapes will not be sufficiently exposed to the sun to ripen. But the Peronospora arrives, with us, at a period when the vine has attained its growth for the season; the important point being then to ripen up the grapes which are concealed by the foliage. By shrivelling up the leaves, the Peronospora enables the sun to reach the grapes without loss to the vines, as is shown by the fact that the vines continue to live on, year after year, without apparent injury. Should the fungus be introduced into Central Europe, the case might be different. The foliage of *Vitis vinifera* is by no means as luxuriant as that of our own vines; the winters are warmer, the springs earlier, and the summers much moister, than here; and it is quite possible that the advent of the Peronospora, by reason of the greater warmth and moisture, would be some weeks earlier than here, before the vine had attained its growth, and at a time when the leaves are needed for the work of absorption and assimilation. It might be that the introduction of *Peronospora viticola* into Europe would prove a repetition, on a small scale, of what has, unfortunately, already happened in the case of Phylloxera. The presence of *Peronospora viticola* is no protection against what is in this country called *Oidium Tuckeri*, for we have found both plants growing side by side on a leaf of *Vitis cordifolia*.

The fungus we are now considering was probably first collected by Schweinitz, who erroneously considered it *Botrytis cana*, Lk., in his "Synopsis Fung. Am. Bor.," 2663, No. 25. In the Curtis collection is a Schweinitzian specimen marked *Botrytis cana*, on a grape-leaf. The specimen is well preserved, and there is no doubt of its being the genuine *B. viticola*. The species was named *B. viticola* by Berkeley and Curtis, from specimens collected in 1848, and distributed without a description by Ravenel in his "Fung. Car. Exs.," V. 90. It was referred to by Caspary, in "Monatsbericht der Berliner Akademie," May, 1855; and by Sprague, in "Proc. Bost. Soc. Nat. Hist.," Jan. 6, 1858. It was first described by De Bary, in the "Annales des Sciences," 4th series, 20th volume, p. 125, 1863, as follows: "*P. viticola* (Berk. et Curt.), mycelii tubi crassi, sæpe constricti varicosique (haustoria non vidi). Stipites conidiferi fasciculatim e stomatibus emergentes, graciles, elati, summo apice parum attenuato brevissime semel bisve dichotomi v. trifurcati; sub apice ramos plerumque, 4–6

(raro 3, v. 7) gerentes. Rami primarii plerumque alterni, distantes et exacte distichi, omnes pro stipitis altitudine breves; inferiores plerumque trifurcati divisionibus iterum bis trifurcatis v. quandoque bis dichotomis; ramuli ultimi (quarti) ordinis, æque ac stipitis divisiones apicales, brevissime conico-subulati recti, acuti. Rami primarii superiores minores, inferiorum secundariis v. tertiariis conformes. Rami omnium ordinum angulis rectis patentes, primarii in uno plano divaricati, planum ramificationum secundi ordinis in primario, tertiarorum in primario et secundario perpendiculare. (Rarius rami primarii 2 inferiores oppositi sunt, raro ramulis 2 alterius muniti nec trifurcati, rarissime rami primarii irregulariter sparsi nec distichi sunt.) Conidia parvula, ovoidea, apice lato rotundata v. subtruncata, papilla destituta, membrana circumcirca æquali hyalina. Oögonia parva, membrana tenui hyalina v. lutescente oösporam foventia subglobosam episporio tenui fuscente diaphano lævi munitam."

It is again referred to as a Botrytis by Curtis, in his "List of Plants of North Carolina," 1867; by Peck, in the "Twenty-third Report of the N. Y. State Botanist," for 1869 (pub. 1873); and by Frost, in Tuckerman's "Catalogue of Plants within Thirty Miles of Amherst College," 1875, and Berkeley, in "Grevillea" for March, 1875, "Notices of N. A. Fungi," No. 667, gives the following description:

"*Peronospora viticola*, B. & C. Floccis candidis sursum ramosissimis apicibus breviter emarginatis furcatisve; sporis ovatis. On the under-side of leaves of *Vitis æstivalis*. Santee River, Ravenel, No. 1632; New England, Sprague, No. 5764; Missouri, Dr. Engelmann. Forming orbicular white spots; flocci articulated, much branched above; the apices emarginate, or shortly forked and acute; spores ovate. In those varieties where the leaves are woolly beneath, the spots are less conspicuous."

Although our plant has been considered quite distinct among the species of *Peronospora*, it seems to us that one cannot fail to see a decided resemblance to *P. nivea*, Unger. The conidia differ from those of the latter species in being smaller, and in not having an apical papilla, but resemble them, and those of *P. infestans*, in their mode of germinating. The conidial-bearing hyphæ in *P. viticola* are taller, and comparatively more slender, than in *P. nivea;* but the peculiar tripartite division of the tips, so uniform in *P. viticola*, is also frequently found in *P. nivea*, although in the latter they are much more

attenuated, not densely compact, as in the former. The oöspores of the two species are very much alike. In short, one might almost say that *P. viticola* was *P. nivea*, with the axis and primary branches drawn out, and the ultimate branches contracted.

It has seemed to us desirable to give at the close of the present article an account of the species of Peronospora at present recognized in the United States, although we can make but a beggarly display compared with European countries. It is natural to suppose that our list will be increased as collectors of fungi shall hereafter turn their attention more especially to plants of this order. But, however many species may be added to the number already known, there can be no doubt that the number of individuals is much smaller than in Europe. We have found it difficult to secure specimens for class demonstration, which is never the case in Central Europe, where, early and late, one is tolerably certain of finding several species. *P. parasitica*, Pers., as far as our experience goes, is not common; and we have never found it in company with *Cystopus candidus* on *Capsella*. *P. gangliformis*, Berk., is one of our few comparatively common species; and, unfortunately for market gardeners, it bids fair to become still more common. *P. viticola* must, on the whole, be considered our commonest species, although *P. infestans* is periodically very abundant. In this connection we would call the attention of our readers to the discovery of the oöspores of *Peronospora infestans* by Mr. Worthington G. Smith, in the leaves of American varieties of potatoes, for which he has been awarded a gold medal by the Royal Horticultural Society, of England. As the results of Mr. Smith's discovery have lately appeared in several journals, some of which are accessible to most of the readers of the Bulletin, we need only refer them to the "Gardener's Chronicle" of July 17, 1875, the "Journal of Horticulture and Cottage Gardener," July 22, the "Quarterly Journal of Microscopic Science," for October, 1875, where two photographs are given, and to the "Journal of the Royal Agricultural Society of England," 2d Series, Vol. 11, Part II., No. XXII., where a review of the subject is given by W. Carruthers, F. R. S.

SYNOPSIS OF THE PERONOSPOREÆ OF THE UNITED STATES.

PERONOSPORA.

CONIDIA solitary, borne on the tips of branching filaments, which pass through the stomata into the air. Oöspores spherical, buried in the tissues of the foster-plant.

PERONOSPORA INFESTANS (Mont.), *Botrytis*, *Auct.*, *De Bary*, *Annales des Sciences*, 4 *Sér. Tom.* XX., 1863. Potato-rot fungus. Mycelium slender, haustoria few, conidial-bearing hyphæ irregularly swollen at intervals near the tip. Branches few, irregularly placed, conidia ovoid, apex papillate. Germination usually by means of zoöspores. Oöspores (*Artotrogus hydnosporus*, Mont. fide Berkeley), dark brown, coarsely reticulated. Vide W. G. Smith, "Quarterly Journal of Microscopic Science," Oct. 1875.

Common on potatoes in all the Atlantic and Middle States. In California, near San Francisco, May, 1875, Dr. H. W. Harkness. On tomatoes, Ravenel, South Carolina, September and October, 1859.

PERONOSPORA NIVEA, UNGER. *De Bary, l. c. No.* 2. *P. Umbelliferarum*, *Caspary*, *Monatsbericht*, *Berliner Akad. May*, 1855. *P. macrocarpa Rabenh. Herb. Mycol.* Mycelium torulose. Haustoria numerous, oval. Conidial-bearing hyphæ, fasciculate, 3 to 7 from each stoma. Axis short, simple; branches few, short, at right angles to axis. Tips of ultimate branches loosely bi- or tri-partite. Conidia ellipsoidal, obtusely papillate. Germination by zoöspores. Oöspores rather large, numerous, epispore hyaline or slightly yellow. Plate II., Fig. 4, and Plate III., Figs. 9, 10.

To this species we refer a fungus found by us twice, once at Cambridge, near Fresh Pond, on the under surface of the leaves of *Geranium maculatum*, L., in August, 1874, and again at Wood's Hole, Mass., on the same plant, July, 1875.* It forms large pure white patches between the principal veins. There are two *Peronosporæ* found on species of *Geranium* in Europe, *P. pusilla*, Unger, and *P. conglomerata*, Fuckel. The latter is very different from our species. The former, for a specimen of which, collected by Professor De

* Since the above was sent to press, we have found the same species of *Peronospora* on a leaf of *Geranium Robertianum* amongst the undetermined species of the Curtis Collection, No. 58, without date or locality.

Bary, we are indebted to Dr. C. E. Stahl, is more like our plant, yet different. Of *P. nivea*, Unger, we have a number of specimens on *Ægopodium Podograria*, collected near Strassburg; and, in spite of the fact that, as a rule, the species of *Peronospora* are limited to particular species of phanerogams, or nearly related species, we can see absolutely no difference between European specimens on an Umbellifer and our own on Geranium. De Bary describes *P. nivea* as being only rarely tripartite at the tip, while our European specimens are as often tri- as bi-partite. The same is true of American specimens. The shape and size of the conidia is the same in both specimens. In both the apex is obtusely papillate; and, if there is any difference in the oöspores, it is that the epispore of American specimens is a little the thicker. We have, unfortunately, never seen the germination of the conidia in American specimens.

PERONOSPORA VITICOLA, B. & C. *Botrytis cana, Herb. Schw. De Bary, l. c. No.* 40, *Berkeley, Not. N. A. Fungi, Grevillea, March*, 1875. Ravenel Fung. Car. Exc. V. 90. Grape mould. Mycelium varicose, haustoria abundant, small, spherical. Conidial-bearing hyphæ fasciculate 4–10 from each stoma, axis simple, slightly undulate, branches few on the upper part of axis, short, alternate, beset with secondary and tertiary branchlets. Tips closely tripartite. Conidia oval, destitute of terminal papilla. Germination by zoöspores. Oöspores numerous, small, epispore smooth, slightly yellow. Plate II., Fig. 1. Plate III., Figs. 2 — 8.

Common in the Atlantic and Central States on *Vitis Labrusca*, L., *V. æstivalis*, Michx., *V. cordifolia*, Michx., *V. vulpina*, L., and their cultivated varieties. Oöspores on *V. æstivalis.*

PERONOSPORA GANGLIFORMIS, BERK. *Journal Hort. Soc. London*, 1, *p.* 51, *tab.* 4, *De Bary, l. c. No.* 6. Lettuce mould.

Mycelium slightly torulose. Haustoria ovate, conidial-bearing hyphæ several times dichotomous, slender, swollen at the tip into a round or slightly funnel-shaped body, from the circumference of which radiate several, two to eight, processes, which bear the small roundish conidia. Germination by a terminal tube. Oöspores small roundish, epispore thin, yellow.

Common on lettuce, Watertown, Mass. On *Lactuca altissima*, Bot. Gard. Cambridge, 1874. On *Nabalus albus*, Wood's Hole, Aug. 1875.

PERONOSPORA PARASITICA, PERS. *De Bary, l. c. No.* 7. Mycelium large. Haustoria very large, branching. Conidial-bearing hyphæ repeatedly dichotomous. Ultimate divisions slender, divaricate. Conidia ellipsoid obtuse. Germinal tube given off from any part of conidia. Oöspores round; epispore, slightly yellow, smooth, or slightly rugose.

Cabbage leaves. Society Hill, N. C. March, 1849. Curtis, No. 2259. On *Cardamine rhomboidea*, D. C. Buffalo N. Y., Clinton in 26th Report of N. Y. State Botanist, by Peck. *Lepidium Virginicum*, L., Noank, Conn., Aug. 1875.

PERONOSPORA EFFUSA, GREV., *De Bary, l. c. No.* 16. — Mycelium cylindrical. Haustoria filiform. Conidial-bearing hyphæ repeatedly dichotomous. Divisions of ultimate dichotomy unequal, flexuous, recurved. Conidia large, ellipsoidal, dirty-violet, colored. Germination by a lateral tube. Oöspores globular; epispore dark-colored, with irregular projections.

To this species we refer two specimens found among the undetermined fungi of the Curtis collection, labelled "Atriplex, Albany." Besides these, we found at Newton, Mass., August, 1874, a *Peronospora* on the under-surface of leaves of *Plantago major*, with both oöspores and conidia, which is apparently the same species as that on the Atriplex, and which agrees perfectly with European specimens of *P. effusa*, Grev., although that occurs on *Chenopodiaceæ* and *Polygonaceæ*. *P. alta*, Fuckel, of which the oöspores are unknown, occurs on the leaves of *Plantago major*, and the description answers very well to our plant. We must confess, however, that the description of that species also answers remarkably well for our European specimens of *P. effusa* on Chenopodium; and we must consider that our plant whose conidia germinate by means of a lateral filament is *P. effusa*, rather than the somewhat doubtful *P. alta*.

It is possible that the onion-disease so destructive in Connecticut is caused by *Peronospora Schleideniana*, Unger, which is injurious to onions in Europe. We have not, however, been able to examine specimens of the Connecticut disease; nor do we know of any scientific investigation of the subject.

CYSTOPUS.

Conidia in rows, packed closely together, and bursting through the epidermis in spots. Oöspores as in *Peronospora*.

Cystopus candidus (Pers.), *Uredo Auct.* (White-Cabbage Mould). Conidia of uniform size, round. Oöspores large, round, yellowish, marked with flexuous ridges, sometimes reduced to rough papillæ. Common on cruciferous plants, Atlantic and Central States. On *Capsella bursa pastoris*, *Dentaria epiphylla*, *Sinapis nigra* (oöspores), *Turritis*, &c.

Cystopus Bliti, Bivon, *C. Portulaceæ* (*D. C.*), *De Bary*, *l. c. Nos.* 3 *and* 4. Conidia of two kinds, — the terminal larger than the rest, and generally sterile; the rest cylindrical ovoid. Oöspores large, round. Epispore dark-brown, marked with slightly elevated ridges, which, at maturity, form a net-work. Common on different species of *Amaranthus* and on *Portulaca oleracea*.

Cystopus cubicus, Mart., *Uredo candida*, *var. Auct. Berkeley*, *Not. N. A. Fungi*, *Grevillea*, *Dec.*, 1874. Conidia of two kinds, — terminal large and sterile; the rest short, cylindrical. Oöspores round, dark-colored, densely covered with small protuberances. On *Convolvulus panduratus*, *Ipomœa trichocarpa*. On *Convolvulus macrorhiza*, Ohio (vid. Berkeley l. c.). On *Ambrosia artemisiæfolia*, Newton, August, 1874. We should be thankful that there is one fungus, at least, which is injurious to this troublesome weed.

Cystopus spinulosus, De Bary, has been detected by Peck on Cirsium, collected by Hon. G. W. Clinton, near Buffalo, N. Y.

No. 23. — *List of Fungi found in the Vicinity of Boston.* By W. G. Farlow, Assistant Professor of Botany in Harvard University.

The following list makes no pretension to completeness, as will be seen by the small number of species of Basidiomycetes and Ascomycetes reported. It is intended simply as a contribution to our knowledge of the fungi found in the neighborhood of Boston, of which our only sources of information are the papers by Mr. C. J. Sprague, published in the "Proceedings of the Boston Society of Natural History," March 5, 1856, and Jan. 6, 1858, and numbered references to the collections of Mr. C. J. Sprague, Mr. Dennis Murray, and the late Rev. J. L. Russell, in the "Notices of North-American Fungi," by the Rev. M. J. Berkeley, now in course of publication in Grevillea. Of the present list, the species have all come under our own observation within a radius of a few miles of the Bussey Institute, or at Wood's Hole, Mass., where the University summer course in cryptogamic botany was given in the months of July and August, 1875. Occasionally, reference is made to a species from a more remote locality. We have omitted the names of a large number of conidial forms which are known to be states of ascomycetous fungi, since one specific name is, of course, sufficient to indicate a whole series of forms. The nomenclature of the species of *Myxomycetes* has been made to correspond, as far as possible, with that adopted by Dr. J. T. Rostafinski, in his work on that group.

MYXOMYCETES.

Ceratium hydnoides, A. & S. Newton; Wood's Hole. Common.

Ceratium porioides, A. & S. Wood's Hole.

Lycogala epidendron, Fr. Common near Boston. On stumps.

Tubulina cylindrica, D.C. Newton. On pine stumps.

Cribraria vulgaris, Schrad. Newton.

Cribraria purpurea, Schrad. Eastport, Me. October, 1875.

Dictydium cernuum, Schrad. Newton. Rather common.

Reticularia muscorum, Fr. Eastport, Me. October, 1875. On stumps.

Stemonitis fusca, Roth. Common near Boston.

Stemonitis ferruginea, Ehrb. Newton. Common.

LAMPRODERMA COLUMBINUM, Rostafinski. (*Physarum*, Pers.) Eastport, Me. October, 1875.

TILMADOCHE NUTANS, Rostafinski. (*Physarum*, Pers.) Newton; Wood's Hole.

PHYSARUM FARLOWII, Rostafinski. Newton.

PHYSARUM SINUOSUM, Rostafinski. (*Angioridium*, Grev.) Newton; Wood's Hole.

LEOCARPUS VERNICOSUS, Lk. Newton; Wood's Hole. Common.

FULIGO SEPTICA, Rostafinski. (*Æthalium*, Fr.) Common near Boston.

DIDYMIUM CLAVUS, Fr. Bussey Woods.

DIDYMIUM XANTHOPUS, Fr. On moss and dead leaves. Wood's Hole. Common.

DIDERMA GLOBOSUM, Pers. Wood's Hole. On leaves. Common.

TRICHIA CHRYSOSPERMA, D.C. Newton. Common.

TRICHIA PYRIFORMIS, Hoffm. Newton.

HEMITRICHIA CLAVATA, Rostafinski. Newton.

ARCYRIA PUNICEA, Pers. Common.

ARCYRIA NUTANS, Grev. Newton. Wood's Hole. Rather common.

ARCYRIA CINEREA, Fl. Dan. Newton.

LACHNOBOLUS GLOBOSUS, Rostafinski. (*Arcyria*, Schw.) Newton. Common on chestnut burrs and leaves.

MUCORINI.

MUCOR SYZYGITES, De Bary. (*Syzygites megalocarpus*, Ehr., and *Sporodinia grandis*, Lk.) Common on decaying agarics. Wood's Hole; Newton.

MUCOR MUCEDO, L. On all decaying substances.

MUCOR RACEMOSUS, Fres. On horse-dung. Bussey Inst.

MUCOR STOLONIFER, De Bary. (*Ascophora mucedo*, Tode; *Rhizopus nigricans*, Ehr.) On decaying articles of food everywhere.

MUCOR PHYCOMYCES, Berk. (*Phycomyces nitens*, Kze.) Found by Dr. C. F. Folsom in the sewers of Boston; also growing luxuriantly at the Bussey laboratory from specimens sent from Strassburg by Dr. Stahl; Cambridge, on bones.

THAMNIDIUM ELEGANS, Lk. Bussey Inst. On horse-dung.

CHÆTOCLADIUM JONESII, Bk. and Br. Bussey Inst. On horse-dung.

PIPTOCEPHALIS FRESENIANA, De Bary. Bussey Inst. On horse-dung.

MORTIERELLA POLYCEPHALA, Van Tieghem. Bussey Inst. On horse-dung.

PILOBOLUS CRYSTALLINUS, Tode. Bussey Inst. and Cambridge. On horse-dung. Very common.

PERONOSPOREÆ.

Cystopus candidus, Lev. Bussey Inst.; Wood's Hole; Newton. Common on cruciferous plants. Oöspores on Sinapis nigra. Noank, Conn.

Cystopus cubicus, Lev. Conidia and oöspores on Ambrosia artemisiæfolia. Newton.

Cystopus Bliti, Bivon. Common near Boston on species of amaranth.

Peronospora infestans, Mont. Common on potatoes near Boston.

Peronospora viticola, B. & C. On wild and cultivated grape-vines. Common near Boston.

Peronospora nivea, Unger. Cambridge, near Fresh Pond; Wood's Hole. On leaves of Geranium maculatum.

Peronospora gangliformis, Berk. Common on lettuce, Watertown. On Nabalus albus. Wood's Hole.

Peronospora parasitica, Pers. On Lepidium Virginicum. Noank, Conn.

Peronospora effusa, Grev. On leaves of Plantago major. Newton.

UREDINEÆ.

Uromyces macrospora, B. & C. On Lespedeza capitata. Newton; Bussey Woods.

Uromyces Ari (Schw.). On Arisæma triphyllum. Common near Boston.

Uromyces appendiculata, Lev. Bussey Inst. On bean-leaves.

Uromyces apiculosa, Lev. On clover.

Uromyces Hyperici (Schw.). Bussey Woods.

Melampsora salicina, Lev. On willows. Very common near Boston.

Melampsora betulina, Desm. On birches. Common near Boston.

Melampsora populina, Lev. On Populus. Common near Boston.

Puccinia variabilis, Grev. On Nabalus albus. Wood's Hole.

Puccinia Valantiæ, Pers. On Galium. Bussey Woods.

Puccinia Circeæ, Pers. On Circæa Lutetiana.

Puccinia Helianthi, Schw. On leaves of Helianthus annuus. Noank, Conn. Bussey Inst.

Puccinia Prunorum, Lk. On Prunus serotina, and other species of Prunus. Common near Boston.

Puccinia striola, Lk. On species of Carex. Bussey Woods.

Puccinia Graminis, Pers. Everywhere.

Puccinia Sorghi, Schw. Newton.

Puccinia Asteris, Schw. On leaves of Aster. Newton.

Puccinia Peckiana, Howe. On Rubus occidentalis. Bussey Woods.

PUCCINIA ANEMONES, Pers. On Anemone nemorosa. Newton; Bussey Woods. On Thalictrum cornuti, New Haven, Conn.

PHRAGMIDIUM TRIARTICULATUM (B. & C.). Newton. Common on leaves of Potentilla Canadensis.

PHRAGMIDIUM MUCRONATUM, Lk. On cultivated-rose leaves. Bussey Inst.; Newton.

PODISOMA MACROPUS, Schw. On Juniperus Virginiana. Common near Boston.

CRONARTIUM ASCLEPIADEUM, Fr. On Comptonia asplenifolia. Newton; Wood's Hole.

IMPERFECT FORMS BELONGING TO THE UREDINEÆ NOT INCLUDED IN THE SPECIES ENUMERATED ABOVE.

ÆCIDIUM MYRICATUM, Schw. On leaves and stems of Myrica cerifera. Wood's Hole. August.

ÆCIDIUM CONORUM PICEÆ, Rees. This rare fungus was found on two green cones of Abies excelsa, Newton, July, 1874. It is certainly an æcidial form, as has been shown by Rees.

UREDO VACCINIORUM, Schw. Bussey Woods.

USTILAGINEÆ.

USTILAGO SEGETUM, Pers. Newton.

USTILAGO MAYDIS, Lev. Common on corn. Everywhere.

USTILAGO UTRICULOSA, Tul. On Polygonum. Jamaica Plain, Mass.

UROCYSTIS OCCULTA, Preuss. On rye. Newton.

UROCYSTIS POMPHOLIGODES, Sch. On leaves and petioles of Anemone nemorosa. Bussey Woods.

BASIDIOMYCETES.

Sub-order *Gasteromycetes.*

SPHÆROBOLUS STELLATUS, Tode. Newton; Wood's Hole. Common.

CYATHUS STRIATUS, Hoffm. Bussey Woods.

CRUCIBULUM VULGARE, Tul. Common on sticks near Boston.

MITREMYCES LUTESCENS, Schw. Newton. Rare. New Haven. Prof. D. C. Eaton.

SCLERODERMA VULGARE, Fr. Common near Boston.

BOVISTA PLUMBEA, Pers. Wood's Hole; Gay Head.

LYCOPERDON PYRIFORME, Schæff. Common near Boston.

LYCOPERDON GEMMATUM, Batsch. Common near Boston.

LYCOPERDON CŒLATUM, Bull. Wood's Hole. Common. Newton.

LYCOPERDON BOVISTA, L. Newton. Not common. Cambridge.

PHALLUS IMPUDICUS, L. Common near Boston; Wood's Hole.

PHALLUS INDUSIATUS, Bosc. New Haven, Conn. Prof. D. C. Eaton.

Sub-order *Hymenomycetes.*

Dacrymyces stillatus, Fr. Common near Boston.

Tremella foliacea, Pers. Common near Boston.

Calocera cornea, Fr. Newton.

Clavaria Botrytis, Pers. Newton; Wood's Hole.

Clavaria cristata, Holmsk. Wood's Hole.

Clavaria formosa, Pers. Newton; Wood's Hole.

Clavaria abietina, Schum. Newton; Wood's Hole.

Clavaria amethystina, Bull. Newton; Wood's Hole.

Clavaria fusiformis, Sow. Newton.

Cyphella fulva, B. & R. Bussey Woods.

Solenia villosa, Fr. Newton.

Corticium amorphum, Fr. On spruce. Newton.

Corticium Oakesii, B. & C. Newton.

Stereum complicatum, Fr. Bussey Woods.

Stereum purpureum, Pers. Common near Boston.

Stereum hirsutum, Fr. Common near Boston.

Stereum acerinum, Fr. Newton.

Stereum tabacinum, Fr. Newton.

Thelephora anthocephala, Bull. Wood's Hole; Newton.

Thelephora Cladonia, Fr. Wood's Hole.

Thelephora pallida, Schw. Wood's Hole; Newton. Common.

Thelephora terrestris, Ehr. Wood's Hole.

Craterellus cornucopioides, Pers. Common near Boston.

Kneiffia setigera, Fr. Newton.

Irpex sinuosus, Fr. Common near Boston.

Irpex cinnamomeus, Fr. Common near Boston.

Hydnum imbricatum, L. Wood's Hole. Common.

Hydnum repandum, L. Common near Boston.

Hydnum compactum, Fr. Wood's Hole; Newton. Not very common.

Hydnum aurantiacum, Fr. Newton.

Hydnum ferrugineum, Fr. Newton; Wood's Hole. Not uncommon.

Hydnum zonatum, Batsch. Wood's Hole; Newton. More common than the last.

Hydnum adustum, Schw. Newton. Tolerably common.

Hydnum auriscalpium, L. On fir-cones. Wood's Hole.

Hydnum (Hydnoglœum, Curr.) gelatinosum, Scop. Winchester, Mass.

Hydnum ochraceum, Pers. Common near Boston.

Fistulina hepatica, Fr. On stumps. Newton. Mason's Island, Conn. Not common.

Merulius lacrymans, Schum. Very common in cellars.

Glœoporus nigropurpurescens, Schw. Newton. Tolerably common.

Dædalea confragosa, P. Newton; Bussey Woods.
Dædalea unicolor, Fr. Everywhere common on stumps.
Polyporus vaporarius, Fr. Newton. Common.
Polyporus vulgaris, Fr. Common near Boston.
Polyporus medulla-panis, Fr. Newton.
Polyporus mucidus, Fr. Newton.
Polyporus contiguus, Fr. Newton. Common.
Polyporus pergameneus, Fr. Bussey Woods.
Polyporus versicolor, Fr. Everywhere.
Polyporus hirsutus, Fr. Common near Boston.
Polyporus cinnabarinus, Fr. Newton, on cherry-trees. Not very common near Boston.
Polyporus igniarius, Fr. Newton; Bussey Woods.
Polyporus fomentarius, Fr. Everywhere common.
Polyporus conchifer, Schw. Common on elm-trees near Boston.
Polyporus adustus, Fr. Bussey Woods.
Polyporus gilvus, Fr. Newton.
Polyporus lacteus, Fr. Newton.
Polyporus epileucus, Fr. Bussey Woods. Common.
Polyporus sulfureus, Fr. Newton; Bussey Woods.
Polyporus cristatus, Fr. Newton. Not common.
Polyporus frondosus, Fr. Bussey Woods.
Polyporus lucidus, Fr. Cambridge; Winchester.
Polyporus Curtisii, Berk. Newton.
Polyporus elegans, Fr. Common near Boston.
Polyporus Boucheanus, Fr. Newton; Wood's Hole. Tolerably common.
Polyporus perennis, Fr. Newton; Wood's Hole. Common.
Polyporus Schweinitzii, Fr. Newton; Bussey Woods; Cambridge, near Fresh Pond.
Polyporus lucidus, B. & C. Near Bussey Inst.
Boletus strobilaceus, Scop. Newton. Rare. Wood's Hole. Common.
Boletus scaber, Bull. Common near Boston.
Boletus edulis, Bull. Common near Boston.
Boletus luridus, Schæff. Newton; Wood's Hole.
Boletus purpureus, Fr. Newton; Wood's Hole.
Boletus retipes, B. & C. Cambridge.
Boletus parasiticus, Bull. On Scleroderma. Cambridge, near Fresh Pond.
Boletus bovinus, L. Newton. Common.
Lenzites tricolor, Fr. Newton. Common.
Lenzites betulina, Fr. Everywhere.
Lenzites Berkeleii, Lev. Bussey Woods.
Lenzites Cratægi, Berk. Newton; Bussey Woods.
Lenzites sepiaria, Fr. Common near Boston.

Schizophyllum commune, Fr. Common near Boston.
Xerotus nigrita, Lev. Bussey Woods; Eastport, Me.
Panus conchatus, Fr. Newton.
Panus stypticus, Fr. Common everywhere near Boston.
Lentinus Lecontei, Fr. Bussey Woods.
Marasmius oreades, Fr. Common near Boston.
Cantharellus cibarius, Fr. Wood's Hole.
Cantharellus tubæformis, Bull. Newton. Common.
Cantharellus (Trogia) crispus, Fr. Newton; Bussey Woods
Russula alutacea, Fr. Common near Boston.
Russula emetica, Fr. Newton.
Russula virescens, Fr. Wood's Hole; Newton. Common.
Lactarius piperatus, Fr. Common near Boston.
Lactarius vellereus, Fr. With the last.
Lactarius Indigo, Fr. Wood's Hole.
Lactarius subdulcis, Fr. Common near Boston.
Hygrophorus cinnabarinus, Fr. Wood's Hole.
Hygrophorus coccineus, Fr. Common on moss near Boston.
Hygrophorus psittacinus, Fr. Newton.
Cortinarius violaceus, Fr. Wood's Hole. Common.
Cortinarius sanguineus, Fr. Newton. Common.
Coprinus comatus, Fr. Cambridge, in gardens. Not common.
Coprinus atramentarius, Bull. Cambridge.
Coprinus micaceus, Fr. Common near Boston.
Coprinus radiatus, Bolt. Common on horse-dung.
Agaricus fascicularis, Huds. Very common.
Agaricus sylvaticus, Schæff. Wood's Hole.
Agaricus campestris, L. Common.
Agaricus tener, Schæff. Common.
Agaricus squarrosus, Müll. Bussey Woods.
Agaricus prunulus, Scop. Newton.
Agaricus ostreatus, Jacq. Newton.
Agaricus laccatus, Scop. Very common.
Agaricus melleus, Vahl. Very common.
Agaricus granulosus, Batsch. Winchester, Mass.
Agaricus cristatus, Bolt. Newton.
Agaricus procerus, Scop. Wood's Hole. Common.
Agaricus vaginatus, Bull. Newton. Common.
Agaricus strobiliformis, Vitt. Newton.
Agaricus muscarius, Fr. Common near Boston.

ASCOMYCETES.

Sub-order *Perisporiaceæ.*

SPHÆROTHECA CASTAGNEI, Lev. On Bidens frondosa, Taraxacum, and Spiræa opulifolia. Near Boston. Common.

PHYLLACTINIA GUTTATA, Lev. On Quercus, Alnus, Corylus, and Carpinus leaves. Very common. Also on barberry-leaves. Newton.

UNCINULA ADUNCA, Lev. On willow-leaves. Common.

UNCINULA SPIRALIS, B. & C. On grape-vines, Amherst, Mass.

UNCINULA CIRCINATA, C. & P. On leaves of Acer rubrum. Common near Boston.

PODOSPHÆRA KUNZEI, Lev. On Spiræa salicifolia and S. tomentosa, and on different species of Prunus. Common.

MICROSPHÆRIA RUSSELLII, Clinton. On Oxalis stricta. Newton.

MICROSPHÆRIA EXTENSA, C. & P. On oak-leaves, near Bussey Inst.

MICROSPHÆRIA PULCHRA, C. & P. On Cornus alternifolia. Common near Boston.

MICROSPHÆRIA HEDWIGII, Lev. On Sambucus Canadensis, near Bussey Inst.

MICROSPHÆRIA PENICILLATA, Lev. On Carpinus, near Bussey Inst.

MICROSPHÆRIA FRIESII, Lev. On Syringa vulgaris. Common near Boston.

ERYSIPHE LAMPROCARPA, Lev. Common on Compositæ.

ERYSIPHE MARTII, Lk. On peas. Bussey Inst.

ERISIPHE COMMUNIS, Schl. On Baptisia tinctoria, Ranunculus, Chelone glabra, &c. Common.

EUROTIUM HERBARIORUM, Lk. Everywhere.

Sub-order *Tuberaceæ.*

ELAPHOMYCES VARIEGATUS, Vitt. Newton. Rare.

ELAPHOMYCES GRANULATUS, Fr. Bussey Woods, Jan., 1876.

PENICILLIUM CRUSTACEUM, Fr. Everywhere.

Sub-order *Helvellaceæ.*

MORCHELLA ESCULENTA, Pers. Newton. Not very common.

GEOGLOSSUM HIRSUTUM, Pers. Newton; Wood's Hole. Common.

MITRULA PALUDOSA, Fr. Newton. Common.

LEOTIA LUBRICA, Pers. Common near Boston.

PEZIZA HEMISPHERICA, Wigg. Wood's Hole.

PEZIZA MACROPUS, Pers. Newton; Wood's Hole.

PEZIZA SCUTELLATA, L. Common near Boston.

PEZIZA AURANTIA, Fr. Common on the ground near Boston.

PEZIZA ÆRUGINOSA, Fr. Common near Boston.

PEZIZA VULGARIS, Fr. Common near Boston.

PEZIZA NIVEA, Fr. Common near Boston.

Peziza virginea, Batsch. Wood's Hole.
Ascobolus furfuraceus, Pers. On dung. Bussey Inst.
Bulgaria inquinans, Fr. Newton; Wood's Hole.
Bulgaria sarcoides, Fr. Newton.
Exoascus Pruni, Fuckel. On plums. Cape Ann.

Sub-order *Phacidiacei.*

Rhytisma Solidaginis, Schw. Wood's Hole.
Rhytisma acerinum, Fr. Newton. Common.

Sub-order *Pyrenomycetes.*

Torrubia Sphingum, Tul. Wood's Hole. Not common.
Torrubia militaris, Fr. Rather common near Boston.
Torrubia ophioglossoides, Tul. On Elaphomyces variegatus. Newton. Rare.
Torrubia capitata, Fr. On Elaphomyces granulatus. Bussey Woods. Not common.
Claviceps purpurea, Tul. On Glyceria and rye. Common.
Hypomyces Lactifluorum (Schw.). Common near Boston.
Hypomyces luteo-virens, Tul. On Boletus. Common near Boston.
Hypomyces chrysospermus, Tul. Common near Boston.
Hypomyces asterophorus, Tul. On Nyctalis. Newton. Wood's Hole.
Nectria cinnabarina, Fr. Very common on dead twigs.
Xylaria polymorpha, Grev. On stumps. Common.
Xylaria hypoxylon, Grev. Common.
Ustulina vulgaris, Tul. Common on dead wood.
Hypoxylon coccineum, Bull. Bussey Woods.
Hypoxylon fuscum, Fr. Common on dead wood.
Hypoxylum nummalarium, Bull. Common.
Dothidea Ulmi, Fr. Very common.
Dothidea graminis, Fr. Everywhere.
Diatrype stigma, Fr. Common.
Diatrype disciformis, Fr. Common.
Sphæria morbosa, Schw. Very common on plum and cherry trees.
Sphæria subiculata, Schw. Newton.
Sphæria Potentillæ, Schw. Common on P. Canadensis.
Cucurbitaria berberidis, Gray. Bussey Woods.
Pleospora herbarum, Rabh. Everywhere.
Pleospora clavariarum, Tul. Bussey Woods.
Monospora vulgaris, Tul. On conidia of Torrubia militaris. Newton.

Imperfect Forms.

Diplodia megalospora, B. & C. On spruce cones. Newton.
Pestalozzia Guepini, Desm. On cranberry leaves. Newton.

Botryosporium pulchrum, Corda. On Dahlia stems. Newton.

Helminthosporium inflatum, B. & C. Newton.

Streptothrix atra, B. & C. On Juniperus Virginiana. Newton. Common.

Rhinotrichum Curtisii, B. On dead wood. Newton. Wood's Hole.

Zygodesmus olivascens, B. & C. On the ground. Wood's Hole.

Zygodesmus fuscus, Corda. Newton. Wood's Hole.

Tricothecium roseum, Fr. Common, Bussey Institution.

Arthrobotrys oligospora, Fres. Bussey Institution.

Volutella ciliata, Fr. On potatoes. Bussey Institution.

No. 24.— *The Black Knot.* By W. G. Farlow, Assistant Professor of Botany in Harvard University.

Without doubt, the most striking disease of vegetable origin occurring on fruit-trees in this country is that commonly known as the black knot. The disease takes its name from the unsightly, black, wart-like excrescences with which every one is familiar on plum-trees and different kinds of wild and cultivated cherries. It is found in all parts of our country east of the Rocky Mountains, and is so common and destructive, that, in some districts, one seldom sees a plum-tree free from the knot. An idea may be formed of the small crop of plums now raised in New England from the fact, that two dollars and a half were given in Boston last autumn for a peck of damsons for preserving. In some parts of New England, particularly in Maine and along the sea-coast, the raising of cherries has also been almost abandoned in consequence of the ravages of the black knot. The disease is peculiar to America, and has been the bane of fruit-growers from early times; but, although much has been written in agricultural papers about its injury to the fruit crop, the subject has been almost entirely neglected by botanists. In the present paper, we shall consider the cause and prevention of the knot, and the question whether the disease is the same on plums and cherries. As a preliminary step, it will be well to trace the development of the knot as it occurs on a single species, and, for this purpose, the choke cherry, *Prunus Virginiana*, L., may be selected.

The choke cherry abounds in all the hedges and thickets of New England, and is recognized by its thin ovate or obovate, abruptly acuminate leaves, and reddish, harsh-tasting fruit, in racemes. In winter, its branches are generally plentifully covered with the knots, which are partly concealed by the foliage in summer. They are black, and vary in size from half an inch to eight or ten inches, or even a foot, in length, and are about two inches in circumference. In some cases, they completely surround the branch on which they are growing, but more frequently they extend only part way round; their course, when very long, being usually somewhat spiral round the stem. If they

extend completely or nearly completely round the branch, the portion above the knot dies. Frequently the upper part of the stem bends over so as to form a right angle with the lower part, and sometimes the portion involved in the knot forms an irregular coil. The surface of the knot is undulated, and flakes of bark not unfrequently adhere to it. In winter, it is more or less cracked and broken open, and the inside is seen to be worm-eaten and hollow, except the woody portion of the stem, which passes through, comparatively sound, generally on one side of the knot.

Below and above the knot, unless the branch above have been completely killed, the stem is swollen for from half an inch to two inches, rarely for a greater distance. Under the microscope, sections show, that, although the bark has been cracked in several places by the expansion of the stem, yet a new layer of bark has formed over the exposed portions. An abundance of mycelial threads are seen extending in streaks from the cambium towards the cuticle. At their outer extremity the bundles of mycelial threads spread out into fan-shaped masses, as shown in Plate VI., Fig. 1. The threads are hyaline, very fine, .0007 mm. in diameter, and are most intricately twisted together in bundles, so that it is almost impossible to say whether there are any cross partitions in them. In longitudinal sections, it is easy to see that they begin in the cambium, and radiate outwards. The threads are found only in the swollen part of the stem; and on the most careful search we have been unable to detect any in the stem, just below the swelling.

CONIDIA. — As spring advances, the mycelial threads increase in size, burst through the bark, and then form the dense pseudo-parenchymatous tissue characteristic of the *Pyrenomycetes* when about to fructify. The knot grows larger, until, about the time the choke cherry flowers, it has nearly the same diameter as the knot of the year before, of which it is an extension. It is not, however, black, but a very dark brownish green. It is solid, rather pulpy, and, on section, a number of radiating lines are seen, as shown in Plate IV., Figs. 2 and 3. With a hand lens, one can see small hemispherical protuberances, which are the beginnings of the perithecia. The whole surface of the protuberances is covered with filaments (Plate V., Fig. 2 *b*), about .04 mm. to .06 mm. in height, and .004 mm. in breadth, which are somewhat flexuous, and frequently divided by cross parti-

tions. The filaments are more frequently simple, but sometimes branch. At the tip of the terminal joint, or more frequently a little to one side, is borne a spore, .006 mm. in length, ovate, and rather sharply pointed at the lower end. Not unfrequently two or three spores are borne on the upper joint, and others may also be produced on some of the lower joints. We have never seen any cross divisions in the conidial spores, which fall very easily from their attachments. The conidia which we have just described spring directly from the surface cells of the perithecia. They continue to bear their spores until the latter part of summer, when they begin to dry up, and, as winter sets in, one finds only their shrivelled remains. The conidia, it will be seen, are of that form which constitutes the genus *Cladosporium* of the older mycologists, or at times the threads are so flexuous as to remind one of species of *Streptothrix*. The genus *Cladosporium*, long ago lost all claims to autonomy, the forms included in it having been shown by Tulasne and others to be the secondary forms of different *Sphæriaceæ*. *Streptothrix*, represented by *S. atra*, B. and C., a common species of this country, will in all probability soon share the fate of *Cladosporium*.

ASCOSPORES. — As the summer advances, the knot grows larger, harder, and more brittle, and is usually attacked by insects of different species, which destroy the central part of the knot, leaving the black outer shell.

It is not until winter, however, that the spores are produced in the asci of the fungus. If we make a section of the outer part of the knot late in the autumn or early in the winter, we shall find that the perithecia are so far developed that one can see the young hyaline asci which line them. We have made no search for a carpogone, as it is evident that the fungus under consideration, owing to its dense, opaque substance, is one of the least favorable for the study of that organ. The asci grow slowly during the winter, and about the middle of January the spores begin to ripen. In the month of February, they are found in perfection; but late in spring they are not so abundant, or in such good condition. We first found a few ripe spores on the 17th of January; and, in the second week of February, most of the knots examined contained ripe spores. In the manner of their production in the asci, the present spores do not differ from those of the other *Pyrenomycetes*. There are eight in each ascus, and they

are discharged through a terminal pore. They are often arranged in a regular row, but quite as often they overlap one another irregularly. The asci themselves are about .12 mm. long, and are rather abruptly contracted at the base. The paraphyses are longer than the asci, unbranched, and club-shaped at the tip. The spores measure from .016 mm. to .02 mm. in length, and from .008 mm. to .010 mm. in breadth. They are two-parted, as shown in Plate VI., Figs. 5 and 6; one division being uniformly much smaller than the other, and not more than one quarter or one third as long. The spores are transparent, and slightly granular. As they lie in the ascus, the small end almost invariably points downward. Spores which ripen in February germinate in the course of from three to five days, when kept sufficiently moist. The first germinal tube grows invariably from the larger of the two divisions of the spore, and generally at the end farthest removed from the smaller division; a second tube grows from the smaller end; and not unfrequently others grow from the sides of the larger division. It must be remarked, that the germinating threads have a diameter three or four times as great as that of the hyphæ in the knot itself.

STYLOSPORES. — Besides the perithecia, with their asci and spores, there are other reproductive bodies found, but not so frequently as the former. Between the ascus-bearing perithecia, we occasionally find cavities whose walls, not so thick as those of the perithecia, are lined with the stylospores, represented in Plate V., Figs. 4 and 5. They sometimes cover the whole surface of the cavity; but more frequently, they are in tufts, or on a sort of irregular placenta, which forms ridges on the walls. The stylospores, using Tulasne's nomenclature, are on very slender hyaline pedicels of different lengths. They are oval, .012 mm. long, by .006 mm. broad, and divided by cross partitions into three parts. When perfectly ripe, they are of a slightly yellowish tinge. The stylospores are of that form which was classed by older writers under the genus *Hendersonia*, which, like *Cladosporium*, is now recognized only as a secondary form of certain *Sphæriaceæ*. We are not able to refer the present form to any described species of *Hendersonia*, and none has hitherto been supposed to be associated with the fungus causing the knot.

SPERMAGONIA. PYCNIDIA. — In winter and spring we find, besides the asci and the stylospores, bodies which must be classed under the

head of spermagonia. Plate VI., Fig. 2, represents a section through a cavity hardly distinguishable externally from the perithecia, which, instead of being filled with asci, is lined with slender filaments, whose tips are somewhat incurved, and easily break off, the central part of the sac being filled with them. We call these spermagonia, from their resemblance to the bodies of the same name in lichens. They are much less common than the conidia, or stylospores. Interspersed amongst the ascus-bearing perithecia, one finds, tolerably frequently, still other cavities which are much more flattened than the perithecia; which often, instead of appearing oval, on section, seem almost triangular. They are lined with short, delicate filaments, which end in a minute oval, hyaline body. These small oval bodies are produced in immense numbers, and are discharged not singly, but in masses. They are more or less closely held together by a sort of jelly, and ooze out from the cavity in which they were produced in the form of tendrils; reminding one of the toy called "Pharaoh's serpent." We have watched the emptying of these bodies, to which we must apply the somewhat vague name of pycnidia, and have found that it sometimes takes as long as two minutes for them to discharge their contents.

If we turn now from the knot on the choke cherry to that on the cultivated cherry and plum, we find a slight difference of aspect, so that, without much trouble, one can say whether a certain knot comes from a cherry or a plum tree. The difference is, however, slight, and not greater than would arise from the different character of the bark through which the fungus has to make its way. A microscopic examination of the knot, in its different stages, shows absolutely no difference between the fungus on cherries and on plums. The conidia are the same, and appear at about the same time; the ascospores are identically the same in both cases, and ripen at the same time; and the mycelium is the same. In short, the microscope fails to show any difference; and, if to the naked eye there appears to be any, it is, as we have said, owing either to the different histological character of the stems of the two trees, or to the greater luxuriance of the growth on one tree than on the other. On the whole, the fungus does not thrive so well on the plum as on the choke cherry, as is shown by the fact that fewer perithecia are formed on the former than on the latter, — a fact observed long ago by Schweinitz.

The knot on the plum is, moreover, attacked early in the season by insects, which modifies its development to a certain extent. The curculio, which makes its appearance early in July, stings the knots as well as the plums, and in the middle of July there exudes from both a gummy substance in great abundance. This gummy substance in a few days becomes covered with the common mould, *Tricothecium roseum*, Lk., which gives its pinkish tinge to a large part of the surface of the knot. On some plum-trees, one can hardly find a knot which has not some of the pinkish color caused by the presence of the *Tricothecium*, which has no organic connection whatever with the fungus which causes the knot, but is simply parasitic on it. It is probably owing to the fact that the curculio stings the knots, that so many persons have been led to believe that the knots themselves are of insect origin. We were greatly astonished last summer, while studying the development of the disease on a certain plum-tree, which, until the first of July, had progressed just as in the neighboring choke cherries, to find, after an absence from town of about ten days, that the whole aspect of the plum knots had been changed by the attacks of the curculio, so that they were hardly recognizable, owing to the gummy masses upon them; while the knot on the cherries remained unchanged. The *Tricothecium* almost immediately made its appearance, and remained on some of the knots until winter.

Anatomy of the Knot. — The histological character of the knot, at its perfection, is very much the same no matter upon what species of *Prunus* it is growing. The granulated surface is composed of the stroma of the fungus we have described, and the mycelium passes inwards in intricately wound bundles, which run in the direction of the medullary rays, and which vary in extent at different stages of growth. The fungus begins to grow in the cambium, either by prolongation from the mycelium of a knot directly above, or by the germination and growth of spores which have fallen on the bark. When the mycelium occupies the cambium of the greater part of the circumference of the stem, the branch above the knot dies, just as though it were girdled. More frequently, the mycelium is found in the cambium of only a part of the circumference of the stem, and that which is free from the mycelium goes on producing wood and bark as usual; and, if in midsummer or winter we make a cross section of a knot on a branch more than a year old,

we shall find one more layer of wood on the sound side of the stem than on the side of the knot. In other words, on one side, the formative power of the cambium has expended itself in forming a new layer of wood and bark (Phloem), and, on the other, irritated by the presence of a fungus, it has produced a mass, the knot, in which all distinction between wood and bark has been lost. In the knot we find bast fibres, wood cells, and dotted ducts; but the prevailing tissue consists of a collection of dotted, rectangular, parenchymatous, cells, with very thick walls, which closely resemble the cells of the medullary rays. These thick-walled cells, by their excessive growth, push the prosenchymatous cells out of their natural direction, parallel with the axis of the branch, and at intervals force their way through them, so that the latter seem to form a series of arcs of circles with the concavities outward. The dotted ducts are numerous, shorter than in the healthy part of the stem, and, owing to the abnormal position into which they are forced, cross sections of the stem frequently show them in lateral view, rather than in section. The separate dotted ducts, instead of lying side by side as usual, are closely twisted or braided together. The bast fibres are less altered in their direction and appearance than the other elements of the stem. The mycelial threads of the fungus form bundles, which are imbedded in the parenchyma of the knot.

The condition of the interior of the knot, in its later stages, is modified very much by the depredations of insects, as well as by the drying and crumbling of the tissue itself. On the wild cherries, the outer part is generally a mere shell, and the internal part is nearly empty. On the plum, the interior is more apt to be honeycombed; and we not unfrequently have a very hard layer next the wood, composed of thick-walled, dotted cells. The knot on cultivated cherries is intermediate between that on the wild cherries and that on plums. The condition of the interior of the knot has an important bearing on the propagation of the disease. Where it is hollow, and the outer part brittle, as in the choke cherry, it is easy to see that the spore-bearing portion will readily be broken up, and the spores blown about without difficulty. Where it is more solid, as in the plum, the spores will be dispersed with much less ease; and we can see how, by the action of the curculio in boring into the knot and making its tissue more spongy, it is facilitating the dispersion of the spores of the fungus when they shall ripen;

and, on the other hand, the knot tends to increase the number of curculios, by offering a suitable place for the deposit of their eggs. As a rule, the trees once attacked by the knot grow more and more diseased, both by the extension downwards and upwards on the stem of the old knots, and by the production of new ones from the germination and growth of spores of the old knots on other branches which have been previously free from them. More and more of the smaller branches are killed by the girdling effect of the knots; and the nutrition of the larger branches is evidently so decidedly impaired, that to bear fruit is entirely out of the question; and, after lingering in a diseased condition for a few years, the trees themselves die. We cannot say certainly for how many years a given knot may continue to elongate; because the older parts crumble, and leave no distinct mark by which the annual growth may be traced. One can, however, often recognize knots which have been growing for at least three years. In a few cases the branches seem able to recover from the knots, and the scars which indicate the previous seat of the disease can be seen.

The fungus causing the knot was first described by Schweinitz, in his "Synopsis Fungorum Carolinæ Superioris," under the name of *Sphæria morbosa*, in the following words: "S. cæspitosa astoma maxima receptaculo bullato fusco, sphærulis minoribus irregularibus albofarctis." At the time Schweinitz wrote, nothing was known of secondary forms of fruit in the *Sphæriæ*. The conidia were first described by Mr. C. H. Peck, in a paper on Botany, read as a report before the Albany Institute, February 6, 1872. He describes the conidial spores as "at first simple, but soon becoming one or more septate." We have never seen them other than simple; but, judging from other Cladosporioid conidia, we should expect the spores to divide at some time. Since Schweinitz's day, the genus Sphæria has been more or less cut up by writers into different genera; and the question naturally occurs, To which of them shall we refer Schweinitz's *Sphæria morbosa?* Curtis, in his Catalogue of Plants of North Carolina, still calls it a *Sphæria;* and places it in the division *Erumpentes*, subdivision *Cæspitosæ*, between *S. nobilis*, B. & C., and *S. Perisporioides*, B. & C., to which, more particularly the latter, it bears but little resemblance. Mr. C. B. Plowright, in "Some Remarks upon Sphæria Morbosa," in the "Monthly Microscopical Journal" for May, 1875, thinks it should be placed in

the genus *Gibbera* near *G. Vaccinii*, Fr. It seems to us, on the whole, premature, so long as the complete history of so many of the different *Sphæriaceæ* remains unknown, to place much confidence in generic characters of that order as at present defined. In estimating the systematic position of any fungus, we must consider all its different states, and any classification based solely on one form of fruit, to the exclusion of others, must be unsatisfactory. The species of *Gibbera* have not yet been sufficiently studied to enable us to define the genus accurately; and we should think it more correct to place the *Sphæria morbosa* of Schweinitz in the genus *Cucurbitaria*, some of the species of which — as *C. Laburni*, De Not., — it resembles in the stylospores and pycnidia, although the ascospores are different. The ascospores of the different species of *Cucurbitaria*, however, vary very much in appearance. We prefer to retain the generic name *Sphæria* for the present, and wait until the genera of *Sphæriaceæ* assume a more definite character, before changing it.

Turning, now, from the botanical side of the case, to the knot as a destroyer of fruit-trees, there is no end to the articles which have appeared in the journals, speculating on its cause or suggesting a remedy. We occasionally hear that the knot is a recent disease; but Mr. J. Buell states * that, in 1811, the plum-trees in Kingston, Mass., were almost all destroyed by the knot. Schweinitz,† speaking of its effects in 1822, says: "Morbum lethalem Cerasorum et omnium Prunorum effecit." In 1831,‡ he again refers to the *Sphæria morbosa* as being much more common in Pennsylvania than in Carolina, and as being particularly injurious to cherries, which he calls in Latin "Amarellæ," probably Morellos, and to the Hungarian and Reine Claude plums. From the sentence, "Nuperrime autem et in his omnibus Cynips fungusque incepiunt sævire et quidem magnitudine semper maxime aucta, sistentes tumores ad sesquipedalem longitudinem extensos," it appears that he regarded the black knots as caused by the combined action of insects and *Sphæria morbosa*. In 1819, Prof. W. D. Peck, of Cambridge, published an account of the insects found in the knots of cherry-trees, which he regarded as the cause of the knot itself. Dr. Joel Burnett, of Southboro', Mass.,§ was one of the first to

* "New England Farmer," Jan. 20, 1826.
† "Syn. Fung. Car.," p. 40, No. 134.
‡ "Syn. Fung. Am. Bor.," p. 204, No. 1416, 269.
§ "New England Farmer," Aug. 16, 1843.

assert that the knot was caused by a fungus rather than an insect, although his belief that the fungus originated in a morbid condition of the plum itself was incorrect. In the second edition of his "Insects Injurious to Vegetation," Harris is somewhat non-committal, although he goes so far as to admit, that, "whatever be their [the knots] origin and seat, they form an appropriate bed for the growth of numerous little parasitical plants or *fungi*, to which botanists give the name of Sphæria morbosa." He also significantly adds: "It is worthy of remark, that they are sure to appear on the warts in due time, and that they are never found on any other part of the tree."

More recently, the belief in the insect origin of the knots has been given up by entomologists, although it is still generally held by fruit-raisers. One of the most prominent entomologists who has, in recent years, written on the nature of the black knot, is Mr. B. D. Walsh.* He is of the opinion that the knot is not caused by any insect, but by a fungus whose spores ripen in July. From this statement, we might infer that he had seen the conidia, although he does not describe them so that they can be recognized. If, however, what he saw were the conidia, his statement that they extend down over the stem below the knot is incorrect. He went too far in asserting that there were two distinct kinds of black knot: one on plums, and another on cherries. He was led to this conclusion, apparently, rather by statements of other persons as to the communicability of the disease from plums to cherries, and *vice versâ*, than from any direct observation on the structure of the knot. In a review of Walsh's article,† the writer goes still farther from the fact in suggesting that there is a third kind of fungus on *Prunus Chickasa.*

The best and so far as we know the only correct statement of the etiology of the black knot, was made by Mr. C. H. Peck,‡ who, as we have already remarked, was the first to describe the conidial state of the fungus. He also first showed definitely when the ascospores ripened, and correctly reasoned that the knot was caused by the *Sphæria morbosa*, and that the fungus on plums and cherries was the same.

* "The Practical Entomologist," March 26, 1866, and March, 1867.

† "Entomologist and Botanist," Vol. II., p. 231.

‡ A Paper on Botany read as a Report before the Albany Institute, February 6, 1872.

The reasons for believing that the knot is not caused by insects may be summed up as follows: First, the knots do not resemble the galls made by any known insect. Secondly, although insects or remains of insects are generally found in old knots, in most cases no insects at all are found in them when young. Thirdly, the insects that have been found by entomologists in the knots are not all of one species, but of several different species, which are also found on trees which are never affected by the knot. On the other hand, we never have the black knot without the *Sphæria morbosa*, as was admitted by Harris;* and the mycelium of that fungus is found in the slightly swollen stem long before any thing which could be called a knot has made its appearance. Furthermore, the *Sphæria morbosa* is not known to occur anywhere except in connection with the knots.

That the fungus on the cherry and plum is the same, as far as all its microscopic characters are concerned, is certain beyond a doubt. The only reason why there has appeared to be any doubt on this subject is, that some kinds of cherries are susceptible to the knot, and others are not. Those who believe that there are two different fungi which produce the knot, have started with the assumption that what is true of one kind of cherry, as far as susceptibility to disease is concerned, is true of all cherries. Having seen some cherries free from the knot, although growing near diseased plum-trees, and others, perhaps not near any plum-trees, covered with knots, they have jumped at the conclusion, that there must be two different fungi producing the knot: one on the cherry, derived from the wild cherry; another on the plum, derived from the wild plum. Now, we have no right whatever to infer that a disease of fungoid origin will be found on plants closely related botanically. In fact, we have no right to infer any thing; we can only examine and find out what the fact is. Let us see, first, how the case stands with our wild cherries, as the species are well marked, and we know more exactly what we are talking about than when we speak of the confused cultivated varieties. *Prunus serotina*, Ehrhart, the rum cherry, and *Prunus Virginiana*, L., the choke cherry, are about equally common near Boston. The latter is very frequently attacked by the knot; the former never, as far as our experience goes, and we have examined hundreds of trees. Walsh and others also testify to the same effect. The following is a striking illustration: In

* *Vide* quotation on page 449.

the month of March, 1875, we went to a hedge of wild cherries, in search of specimens of the knot, but found them only on one tree, although very abundant on that. When the trees had leaved out, a few weeks later, we passed by the hedge and observed that all the trees but one were *Prunus serotina;* and that one (the same from which we had gathered specimens of the knot) was *P. Virginiana.*

Prunus Pennsylvanica, L., the bird cherry, is subject to the disease; and, also, *Prunus Americana*, Marsh, the wild plum, on the authority of Prof. C. E. Bessey, Walsh, and others. Harris makes the statement that the last-named species is not subject to the knot; but he was probably mistaken, as so many others affirm the contrary. *Prunus maritima*, Wang, the beach plum, as far as our experience in southern Massachusetts goes, is free from the knot. Of *Prunus Chickasa*, Michx., we have no definite information. The single case reported by Walsh of a black knot occurring on a peach-tree is extremely doubtful.

If we turn now to the cultivated varieties of plums and cherries, we also find that some are susceptible to the disease and others are not. Without doubt, the morello cherry is more susceptible than any other variety, and next in order comes the mazzard. Whether any other varieties of cultivated cherries are liable to the knot, we cannot say, speaking from our own experience, and the accounts published in the journals are so indefinite and contradictory that one does not know what to believe. That some varieties are free from the disease, we know to be a fact; for we have very frequently seen orchards of other varieties than the morello and black mazzard entirely free from the knot, although, in some cases, infected choke cherries were actually growing under the cultivated trees, and plum-trees in the neighborhood were badly diseased.

We have little hesitation in asserting, judging from our observations and the more reliable reports in the agricultural journals, that there is no variety of cultivated plum which is not subject to the black knot. To suppose that the disease came from the wild plum, rather than the wild cherry, is quite superfluous; for, in the region of Boston, where the black knot has almost completely destroyed the cultivated plums, the wild plum is very rare, if it occurs at all, and the disease must have come from the choke cherry or the bird cherry. We have made direct experiments to show that the spores of the knot on the choke cherry will germinate and produce the knot in healthy plum-trees, and the results will be given in a future number of the Bulletin.

PREVENTION OF THE DISEASE. — From the knowledge that the knot is a contagious disease, caused by a fungus whose ascospores are ripened in midwinter, and whose mycelium does not extend for more than a few inches below the knots, and bearing in mind that the fungus is indigenous on certain of our native species of Prunus, the remedy is obvious. When a knot makes its appearance, the branch should be cut off a short distance below the slight swelling of the stem, which is found just below the knot. When cut off, the branches should be burnt, to prevent the spores from spreading the disease; for, although the asci may have but begun to form when the branch is cut off, they will grow and ripen their spores even when separated from the trees, as we know from experience.* The question arises as to the best time for cutting off the diseased branches. We should say, cut them off whenever one sees them. The most favorable time is late in the autumn, before the ascospores are ripe. But it must not be forgotten that the conidia ripen in early summer; and, if knots are seen in the spring, they should be cut off at once.

Not only should diseased branches of cultivated cherries and plums be removed; but all means should be taken to destroy the choke cherry, the bird cherry, and the wild plum, in the neighborhood of orchards. In New England, particularly, the choke cherry can only be regarded as a pest. We notice that Mr. Emerson, in the new edition of his "Trees and Shrubs of Massachusetts," recommends the choke cherry as worthy of cultivation on account of its beauty. However opinions may differ as to its beauty, there can be only one as to its injurious influence on cherry and plum orchards; and it cannot be too strongly impressed upon fruit-growers, that the choke cherry is a most dangerous enemy, and should be destroyed. It is quite time that it was generally understood, that many of our herbaceous and shrubby plants cause or, at any rate, increase disease in our vegetables and fruit-trees. The farmer destroys caterpillars wherever and whenever he finds them; why should he not also cut down and destroy all trees and shrubs which carry a contagious disease into his fruit orchards?

* A plum-tree covered with knots was cut down at Newton, Mass., towards the end of the summer of 1875, before the ascospores had begun to form; but by the first of the following March ripe spores were formed in all the knots, notwithstanding the fact that on the first of the previous December the tree had been exposed to a temperature of — 8° F.

In the preceding pages, we have attempted to dispel a certain mystery which hangs about the black knot in the minds of fruit-raisers, and to convince them that it is amenable to treatment. We can hardly expect, seeing how wide-spread the disease is in the eastern part of our country, that it will be entirely driven off, except by extraordinary exertions on the part of fruit-raisers. Knowing, however, where it comes from and how it is propagated, there can be no possible excuse for allowing it to spread to parts of the country which are at present free from the disease. The disease is as yet unknown in Europe, and there is little probability that it will be introduced by the importation of cultivated American varieties of plums or cherries. It is more likely to find its way to Europe on our wild species which may be introduced into the different botanical gardens, and the directors of such gardens should be very cautious about importing *Prunus Virginiana*, *P. Americana*, or *P. Pennsylvanica;* for the black knot would prove an unwelcome guest, in comparison with which the now notorious Babington's curse would seem insignificant.

EXPLANATION OF PLATES.

Plate I.

Fumago salicina, Tul., on olive leaves, magnified 600 diam.

1. Stylospores.
2. Mycelium on scale of leaf.
3. *a*, pycnidia; *c*, conidia.

Plate II.

1. Peronospora viticola, B. and C., conidia magnified 600 diam.
2. Tip of branch more highly magnified.
3. Haustoria in stem of Vitis cordifolia.
4. Conidia of Peronospora nivea, Unger, from leaf of Geranium maculatum.
5. Conidia of Peronospora effusa, Grev., from leaf of Plantago major.
6. Conidial spore germinating.

Plate III.

1. Oöspore of Peronospora effusa, Grev., from leaf of Plantago major, magnified 750 diam.

2. Oöspore of Peronospora viticola, from Vitis æstivalis.

3, 4, 5, 6, 7, 8. Different stages of development of the zoöspores of P. viticola; 8 is drawn on a larger scale than 6 and 7.

Plate IV.

1. Sphæria morbosa, Schw., black knot on cultivated plum. May. Natural size.

2 and 3. Sections of young knot from a choke cherry. Natural size.

Plate V.

1. Sphæria morbosa on cultivated plum. Autumn. Natural size.

2. Section of knot on choke cherry in May, magnified 600 diam. *a*, mycelium; *b*, conidia.

3. Conidia more highly magnified.

4. Section through one side of cavity containing stylospores. From mazzard cherry.

5. Stylospores more highly magnified.

Plate VI.

1. Section of choke cherry stem, showing mycelium before it has come to the surface, magnified 600 diam.

2. Spermagonia.

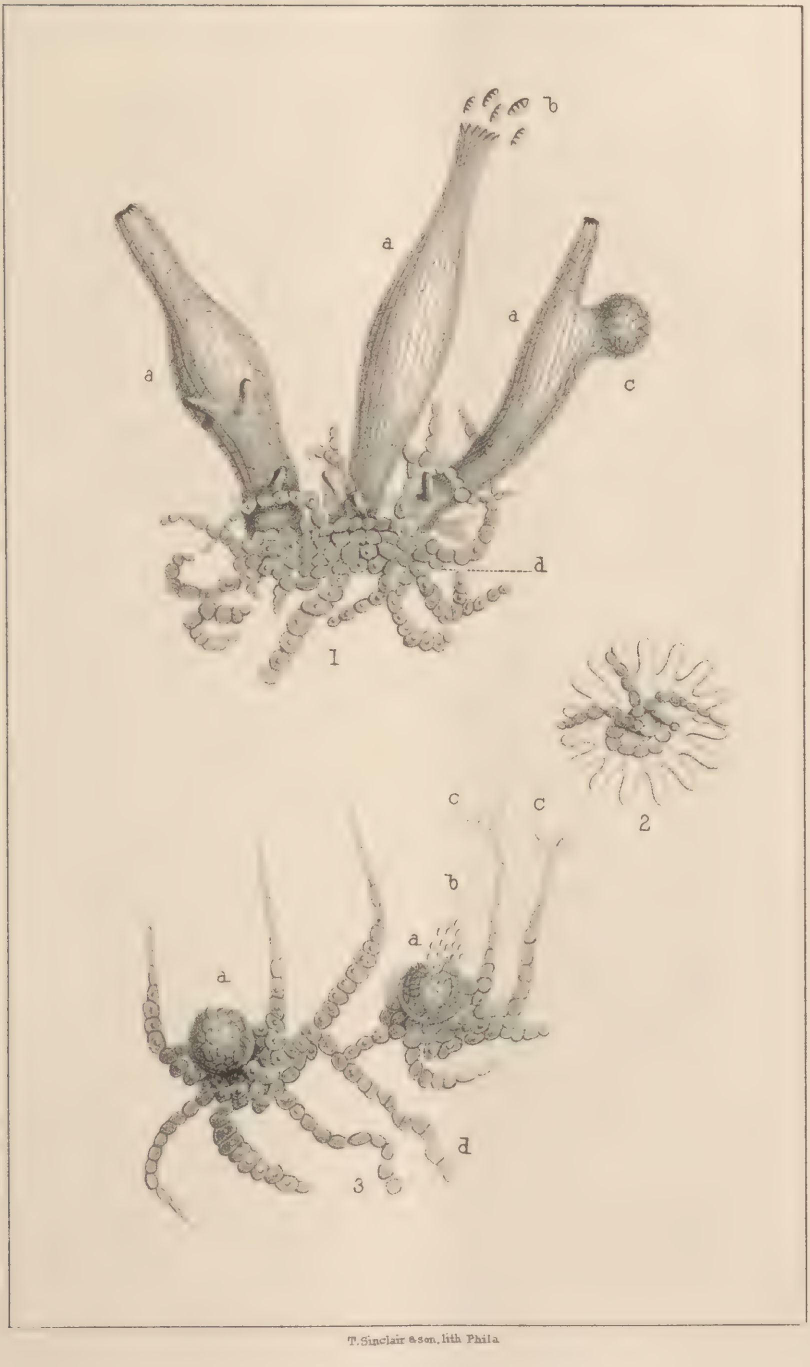
3. Asci and spores of Sphæria morbosa from choke cherry.

4. Perithecium with asci.

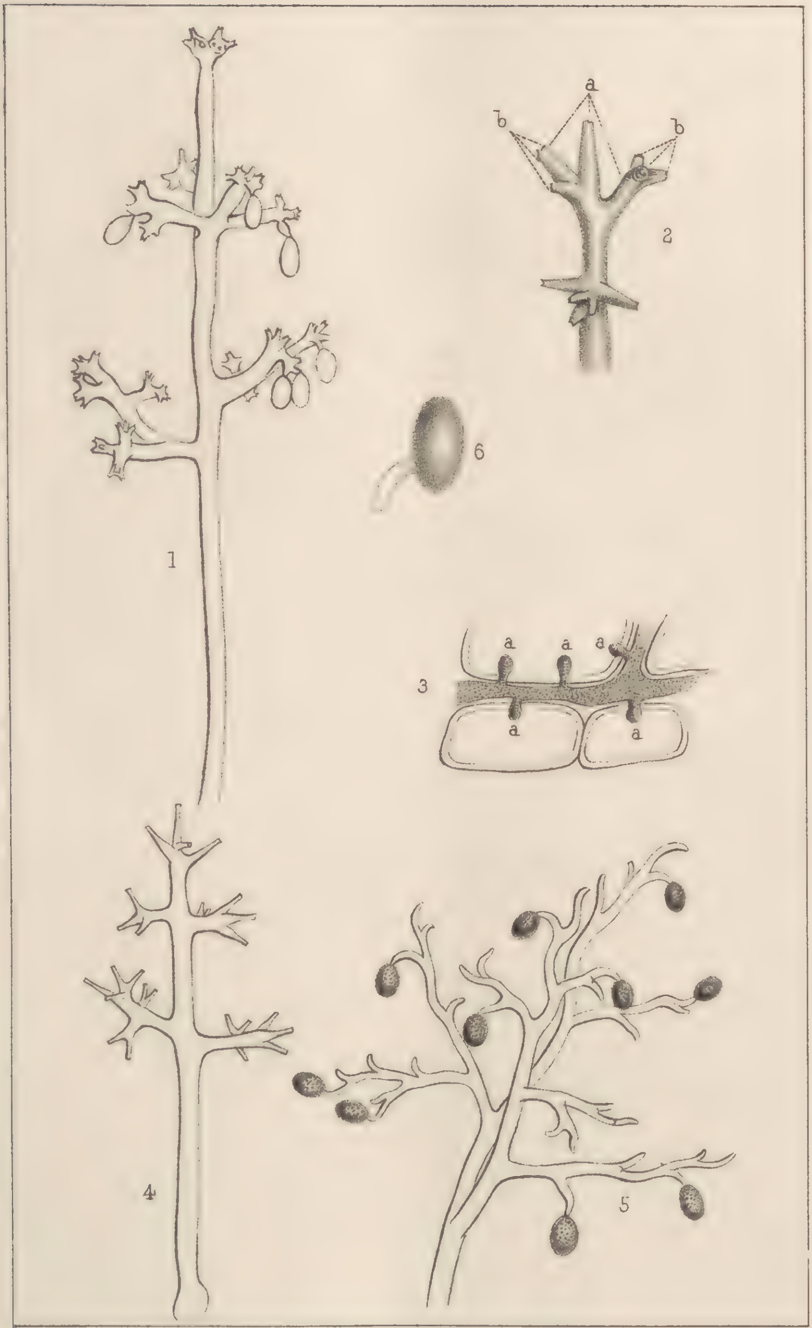
4, 5. Ripe ascospores.

6, 7. Ascospores germinating.

PLATE I.

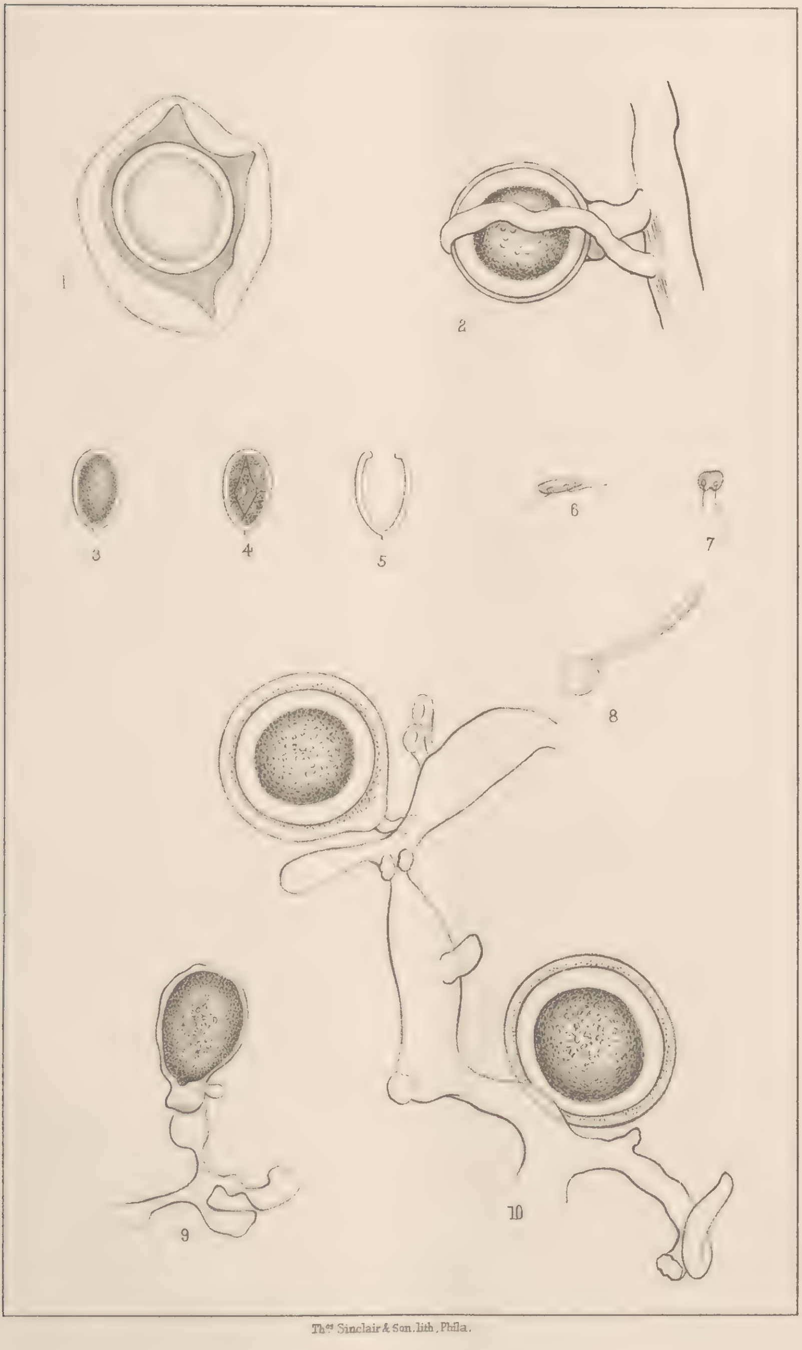


T. Sinclair & son, lith Phila



T Sinclair & Son, lith. Phila.

PLATE III.



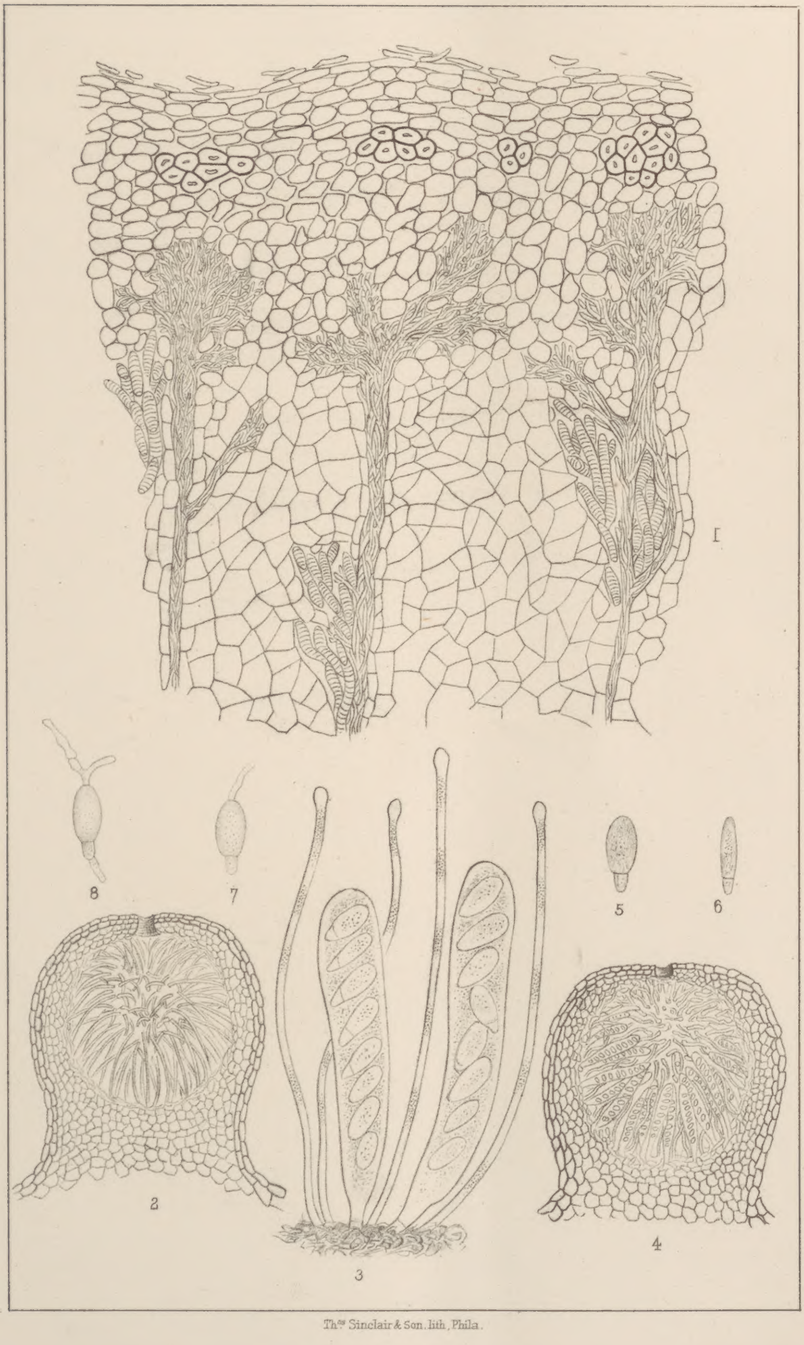
Thos Sinclair & Son, lith, Phila.

T. Sinclair & Son, lith. Phila.

PLATE V

T. Sinclair & Son, lith Phila.

PLATE VI.



Thos Sinclair & Son. lith, Phila.